Guidance Document for Wellhead Protection
Regulation 1200-5-1-.34
Tennessee Department of Environment and Conservation

Division of Water Supply
May 1994

TENNESSEE WELLHEAD PROTECTION GUIDANCE DOCUMENT

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1.0 General Background of the Wellhead Protection Program

Many of the federal environmental laws in effect today are the result of Congressional response to incidences of various types of environmental pollution around the country. Congress included requirements for state wellhead protection programs in the 1986 Safe Drinking Water Act amendments because of the increasing number of reports of pollution of public water supplies obtained from ground-water sources.

The Safe Drinking Water Act is administered at the federal level by the U.S. Environmental Protection Agency (EPA). Each state is required to develop its own unique program following criteria set forth in the Section 1428 of the 1986 Safe Drinking Water Act Amendments:

States at a minimum are to:

a. specify roles and duties of State agencies, local government entities and public suppliers, with respect to wellhead protection programs;

b. delineate the wellhead protection area for each wellhead;

c. identify potential sources of contaminants within each wellhead protection area;

d. develop management approaches to protect the water supply within wellhead protection areas from such contaminants;

e. develop contingency plans for each public water supply system to respond to well or well-field contamination;

f. site new wells properly to maximize yield and minimize potential contamination; and

g. ensure public participation in the wellhead protection program.

The Tennessee Department of Environment and Conservation has developed regulations for a mandatory statewide wellhead protection program to protect the various public ground water supplies. Wellhead Protection is a focal point in the overall goal to develop a Comprehensive State Ground Water Protection Plan for Tennessee, with an emphasis on preventing ground water contamination. Tennessee's Wellhead Protection Program will require the cooperation of state and local government, private industry and the general public.

1.1 The Need for Wellhead Protection

The ultimate success or failure of Tennessee's Wellhead Protection Program will depend on the development and implementation of good local management plans for every designated wellhead protection area in the state. The need for such plans is real. It is extremely costly to develop new water supplies, remediate contaminated ground water, or add additional treatment at the Public Water System (PWS).

There have been a very limited number of PWS contamination incidences in Tennessee, but Tennessee cannot rely on continued good fortune. It is critical that Tennessee's citizens continue to have safe public water supplies at a reasonable cost.

The benefit for Public Water Systems (PWS) specifically written into Tennessee's Wellhead Protection Regulations is that of decreased monitoring costs through monitoring waivers for those PWS with approved Wellhead Protection Programs. Monitoring under the new Phase V Rule is particularly burdensome to the smaller PWS, as much as $4,000 per quarter for four quarters.

Over the long term, the PWS will also be avoiding increased treatment costs by playing a role in preventing contamination. Small PWS in particular can ill afford such treatment costs for contaminated ground water sources. EPA estimates that treatment costs for inorganic and synthetic organic compounds found in conjunction with monitoring under the Phase V Rule could range from $1,494 per household per year for systems with less than 100 connections to $186 per household per year for systems with 10,000 connections.

For municipal water supplies, local government has a already significant link to the PWS. With other PWS, local governments still have a role to play in protecting their citizens from increasingly high water treatment and monitoring costs by helping to protect PWS ground water sources from contamination.

1.2 Submittals/Division Contacts

The Division of Water Supply is responsible for Tennessee's Wellhead Protection Regulations. The required submittals should be sent to:

Tennessee Department Environment and Conservation
Division of Water Supply
6th Floor, L & C Tower
401 Church Street
Nashville, Tennessee 37243-1539
(615) 532-0191 or (615) 532-0192

Local Division of Water Supply contacts for the PWS are available within their region:

Jackson
(731) 512-1300

Nashville
(615) 687-7000

Chattanooga
(423) 634-5745

Knoxville
(865) 594-6035

Johnson City
(423) 854-5400

Cookeville
(931) 432-4015

Columbia
(931) 380-3371

If there is any question regarding which environmental assistance center (EAC) to call, Appendix 1 gives which EAC is appropriate for the individual Community PWS, as well as the complete addresses of the EACs. The Department of Environment and Conservation's toll free number 1-888-891-8332 will direct you to the appropriate EAC if the caller is calling from the region of interest.

2.0 Basic Concepts For Wellhead Protection

All ground water PWS will develop their Wellhead Protection Plans and implement their programs according to the time table for their size categories detailed later in this document. Each PWS must:

1) designate two zones of protection for their ground water source;
2) perform a potential contaminant source inventory within those zones; and
3) develop and implement management approaches to protect the water supplies with the help of State and local government agencies.

The ground water which supplies a well or spring has been derived at some point from rainwater which has gone down through the ground to the water table and recharged the aquifer (ground water reservoir). Knowing the area where that water is coming from to reach the well or spring allows us to take precautionary measures to protect that water. The same basic principle applies in ground water as with rivers and streams - water flows downhill. This overriding principle allows us to make predictions about where the water is coming from which supplies a well or spring.

Since the ground water is flowing downhill, water levels in wells will reflect this (see Figure 2.0A), and be lower in the direction of water flow. Spring elevations will also reflect the ground water flow direction. By taking water level measurements from wells and spring elevations in the area around the Public Water System (PWS) well or wellfield (and from the PWS wells themselves), the general direction of ground water flow can be determined around the PWS well.

In West Tennessee sand aquifers (areas west of the Tennessee River/Kentucky Lake; Figure 2.1C in Section 2.1) where water flows relatively evenly between the sand grains, it is even possible to use a computer model to take predictions one step further. Computer modeling can take into account more geologic factors to more accurately assess where the water is coming from that supplies the well.

The basic principle in modeling is being able to estimate the speed (velocity) and direction in which the ground water is traveling (see Figure 2.0B). To some extent, it is like knowing your car is traveling down a particular highway at 60 miles per hour -- in one hour, the car will have gone 60 miles. The modeling required in Tennessee's Wellhead Protection Regulations for West Tennessee aquifers is based upon time of travel -- how far and from which direction the ground water will have traveled in ten years to reach the well (Figure 2.0C, Figure 2.0D).

In the case of ground water, the "car" has no engine but gravity, so that it is more like running a boxcar race. The speed (velocity) of the ground water is based on how steeply downhill (downgradient) the water is flowing to reach the well and how easily it can pass through the material (sand) it is going through (known as the material's hydraulic conductivity). How much water the aquifer can hold also enters in to the equation (porosity -- space available between sand grains; thickness of aquifer) as does how much water is being pumped out of the well. If the aquifer can't store much water (low porosity and thin aquifer), the well is "reaching" further away to get the water that is being pumped.

The pumping well affects the aquifer by drawing down the water table in the vicinity of the well (see next section, Figure 2.1A). This will actually reverse the ground water flow in the very near vicinity of the well and have water flowing back toward the well. This drawdown area where the water table is pulled down is referred to as the cone of depression (the water level is depressed around the well in a cone/funnel shape).

DETERMINING GROUND WATER FLOW DIRECTION
AND RECHARGE ("UPHILL") AREA

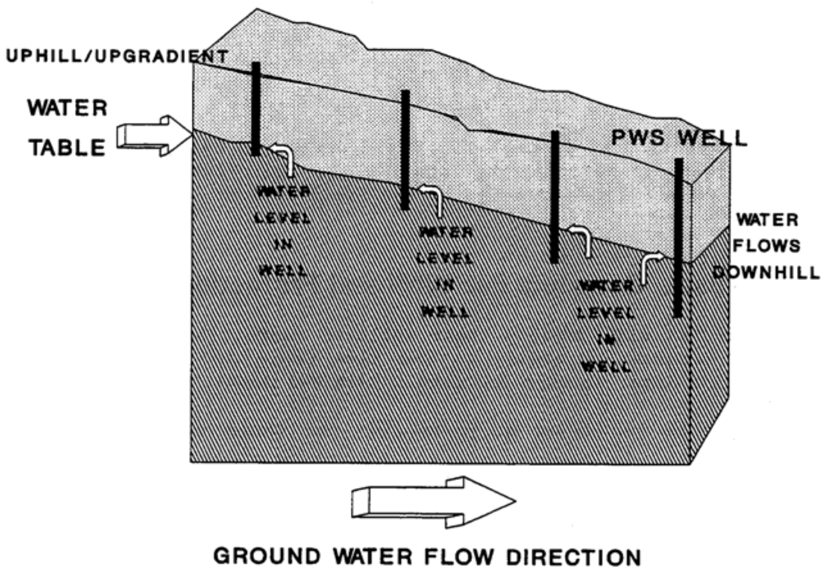


Figure 2.0A

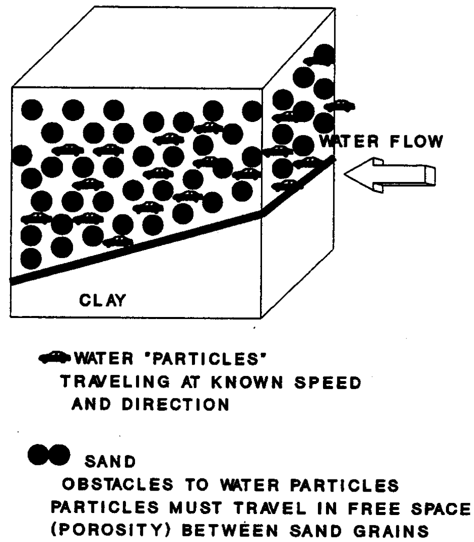


Figure 2.0B

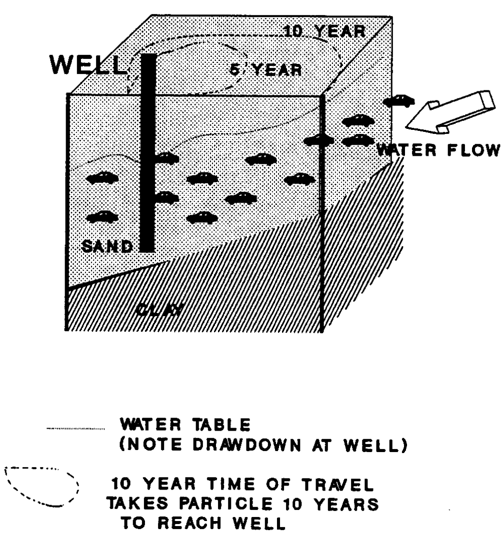
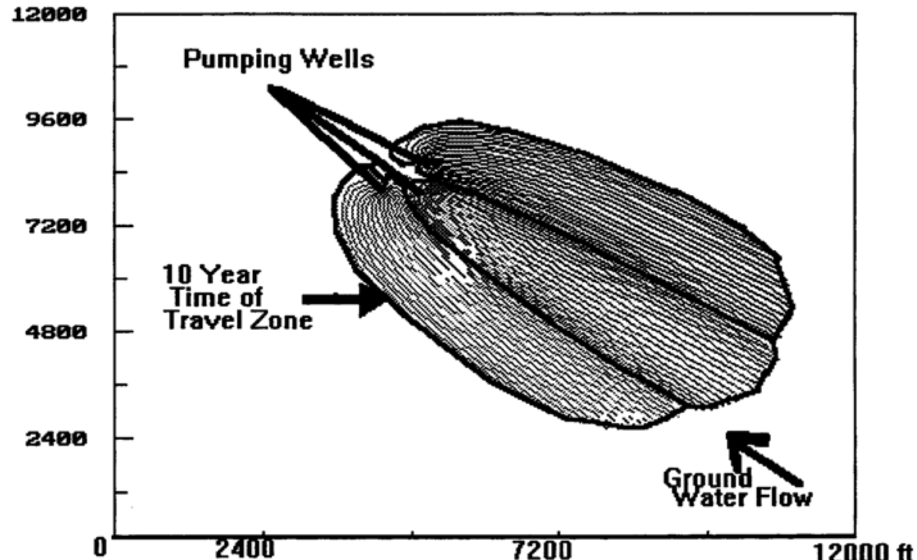


Figure 2.0C

4A



WHPA 2.0 MODEL for West Tennessee Memphis Sand Aquifer
10 Year Time of Travel
Figure 2.0D

2.1 Delineation of Wellhead Protection Areas

The purpose of delineating wellhead protection areas is to define the geographic limits most critical to the protection of a wellfield or spring. Any area that receives recharge that contributes water to a well or spring is known as a "zone of contribution" (Figure 2.1A). Zones of contribution are dependent on well pumping rates and other hydrogeological factors.[1]

For Tennessee's Wellhead Protection Program, the first (innermost) zone of protection is referred to as the Wellhead Protection Zone or Zone 1 (Figure 2.1B). This zone is adjacent to the well or spring and is the area from which the PWS well or spring actively draws its water supply. Contamination within this zone could enter the aquifer alongside the well casing, directly enter the spring or be drawn into the cone of depression of the well. Such contamination is an immediate threat with effectively no time for response actions or natural attenuation before contamination reaches the well.

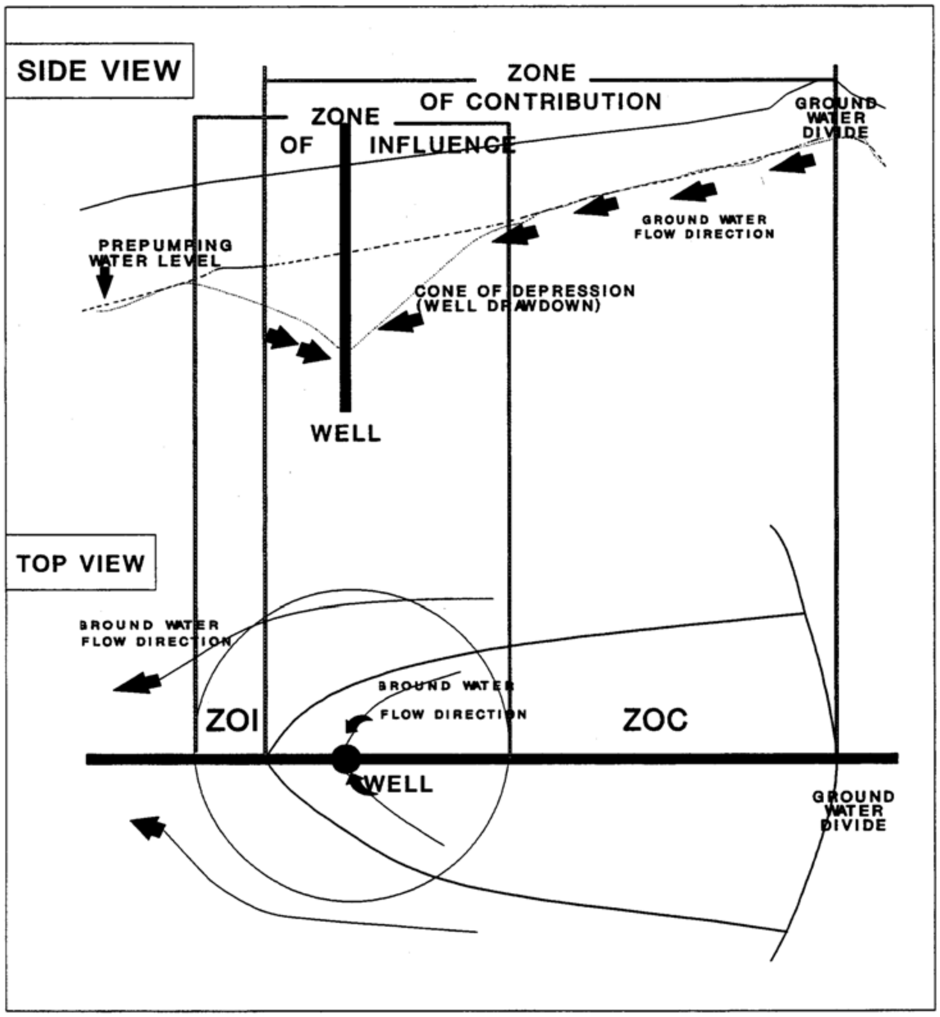
Tennessee's approach is for Zone 1 to initially be a fixed radius based on size categories to simplify delineation, with provisions to allow for later hydrogeologic delineation (see Section 3.0). The fixed radii are derived from the WHPA 2.0 Model taking into account the production rates for the largest supplies and then scaling down for the smaller supplies.

The second (outermost) zone of protection is the Wellhead Management Zone or Zone 2 (Figure 2.1B). This zone surrounding the Wellhead Protection Zone is delineated on the basis of ground water flow direction and recharge, where contamination is likely to move toward and reach the well or spring. The Wellhead Management Zone relates to the zone of contribution.

The varying geology across the State has resulted in very distinctive aquifer types (Figure 2.1C). The two major aquifer types in Tennessee are the sand aquifers of West Tennessee and the karst limestones of Middle and East Tennessee. Appendix 1 gives the geologic setting of the individual Community Public Water Systems.

Karst is characterized by sinkholes, springs, disappearing streams and caves. The term karst refers to limestones and dolomites (magnesium-rich limestones) where the ground water flows through solution-enlarged channels, bedding planes and microfractures within the rock (Figure 2.1D). In contrast, the ground water in the West Tennessee sand aquifers moves through the pore space between the individual sand grains and behaves in a more predictable fashion which lends itself to computer modeling.

For further discussion of the major aquifers in Tennessee, see Appendix 2. Since the occurrences of the ground water in the two major aquifer types are quite distinct, they require different methods to delineate the Wellhead Protection areas for the PWS wells and springs. The modeling method of wellhead protection area delineation applies to those PWS listed in the Appendix 1 with geology as Cretaceous Sand, Alluvial Sand, Tertiary Sand and Tertiary Sand-Confined. The hydrogeologic mapping for karst and fractured rock settings applies to those PWS with geology in the table listed as Cambrian/Ordovician-carbonate, Mississippian Carbonate, Pennsylvanian Sand and Crystalline Rock.



SIDE VIEW
ZONE
OF CONTRIBUTION
ZONE
OF INFLUENCE
GROUND
WATER
DIVIDE
GROUND WATER
FLOW DIRECTION
PREPUMPING
WATER LEVEL
CONE OF DEPRESSION
(WELL DRAWDOWN)
WELL
TOP VIEW
GROUND WATER
FLOW DIRECTION
GROUND WATER
FLOW DIRECTION
ZOI
ZOC
WELL
GROUND
WATER
DIVIDE

Figure 2.1A

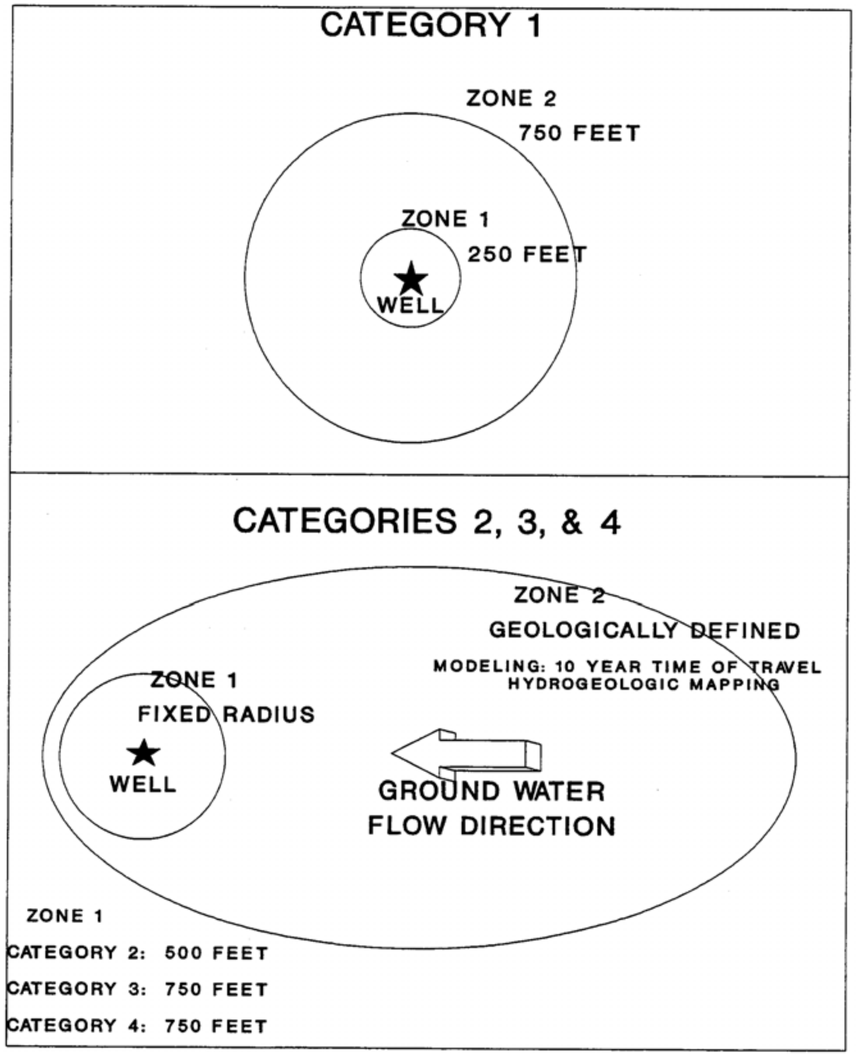


FIGURE 2.1B: CATEGORY ZONES

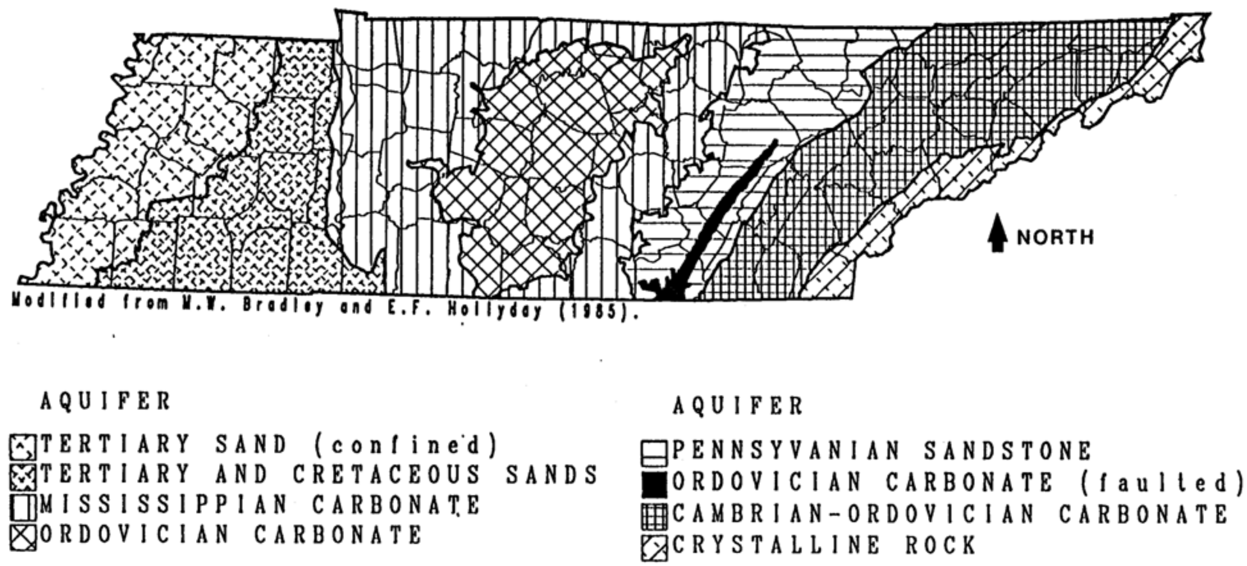


Figure 2.1C–Principal Aquifers of Tennessee with County Boundary Overlay.

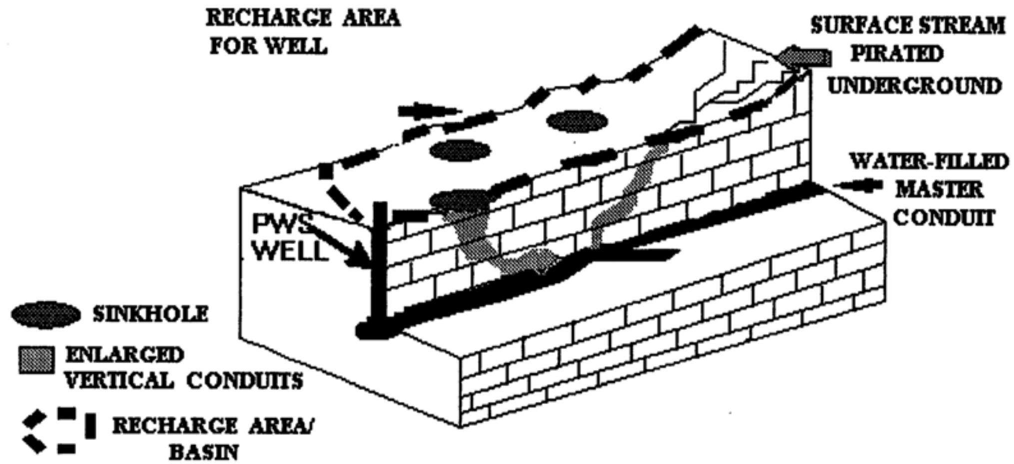


FIGURE 2.1D RECHARGE AREA IN KARST

2.2 Sources of Ground Water Contamination

Ground water can become contaminated from natural sources or numerous types of human activities. Residential, municipal, commercial, industrial, and agricultural activities can all affect ground water quality. Contaminants may reach ground water from activities on the land surface, such as industrial waste storage or spills; from sources below the land surface but above the water table, such as septic systems; from structures beneath the water table, such as wells; or from contaminated recharge water.

2.3 Public Education and Institutional Controls

The Wellhead Protection Plan developed by the PWS must include public education and participation, solicitation of local government for the possibility of developing local ordinances and local zoning considerations, as well as requesting review and comment privileges for issues within the wellhead protection areas. The PWS are expected to observe the activities within the wellhead protection area and pass on pertinent information to a coordinated state regulatory committee. These areas are addressed later in this document. In addition, the plans must also include provisions for periodic updating.

2.4 Timeframe for Development of Wellhead Protection Plans

2.4.1 PWS Size Categories

Requirements and deadlines for the PWS are dependent upon the size of the individual PWS. The following table provides the category breakdowns:

TABLE 2.4.1A
PUBLIC WATER SYSTEM CATEGORIES

CATEGORY 1:	(a)	Community PWS with less than 100 connections and less than 20,000 gallons per day (gpd) average daily production
	(b)	All Noncommunity PWS
CATEGORY 2:	(a)	Community PWS with 100 to 999 connections and less than 315,000 gpd average daily production.
	(b)	Community PWS with less than 100 connections and 20,000 to 314,999 gpd average daily production.
CATEGORY 3:	(a)	Community PWS with 1000 to 2999 connections and less than 1,000,000 gpd average daily production.
	(b)	Community PWS with less than 1000 connections and 315,000 to 999,999 gpd average daily production.

TABLE 2.4.1A (continued)
PUBLIC WATER SYSTEM CATEGORIES

CATEGORY 4:	(a)	Community PWS with 3,000 or more connections.
	(b)	Community PWS with less than 3,000 connections and 1,000,000 gpd or greater average daily production.

A table of Community Public Water Systems has been provided in the Appendix which gives the PWS which category it is in based on Table 2.4.1 as well as other pertinent information. *Size categories are based on connections and average production rates for the entire system and not a particular well or wellfield.*

2.4.2 Wellhead Plan Development Schedule

The first deadline for the Wellhead Protection Regulations falls 4 months after the promulgation of the Wellhead Protection Regulations (scheduled to be January 6, 1994). Regulation 1200-5-1-.34(1)(f)5. requires the following to be accomplished by May 6, 1994 (4 months from the January 6, 1994 promulgation):

> Each PWS shall notify the governing county body and county/regional planning commission of the designation of the Zones in Rule 1200-5-1-.34(1)(f)3. & 4., per the Tennessee Safe Drinking Water Act, T.C.A. 68-221-701 et seq. within four (4) months of the effective date of this rule. For Category 1 PWS this shall include both Zone 1 and Zone 2 , followed by a copy of the Wellhead Protection Plan upon the Plan's completion. For Categories 2, 3 and 4, the initial notification shall only apply to Zone 1 followed by a copy of the Wellhead Protection Plan which includes both zones at the Plan's completion. The PWS shall describe the concept of Wellhead Protection and Wellhead Management Zones and provide a topographic map or other suitable map of a scale of 1:24000 (1 inch = 2000 feet) or better with the designated area marked. The PWS shall also provide a statement of the intent to pursue a Wellhead Protection Program, soliciting the governing body and planning commission's cooperation.

A sample letter to local government has been included as Appendix 10. The schedule for completion of the various phases of the Wellhead Protection Plan for the PWS of the four size categories is as follows:

Table 2.4.2A
IMPLEMENTATION SCHEDULE*

	Submit WHP Area Proposal	Submit Contaminant Source Inventory	Plan Submittal
Category 4:	July 1, 1995	March 1, 1996	May 1, 1997
Category 3:	May 1, 1995	Jan. 1, 1996	March 1, 1997
Category 2:	Sept. 1, 1996**	May 1, 1997	Nov. 1, 1997
Category 1:			
Community:		May 1, 1995	May 1, 1995
Noncommunity:		Nov. 1, 1995	Nov. 1, 1995

* Based on Guidance Document distribution by May 1, 1994.

** Additional deadline for Category 2: field work completion by August 1, 1995 for technical assistance in modeling Wellhead Protection area by Department

Two copies of the required submittals should be sent to the Division of Water Supply, one to the address specified previously and the other to the appropriate Environmental Assistance Center. The first submittal required for each PWS should be in a large three-ring notebook such that subsequent submittals (contaminant source inventory and wellhead protection plan) can be inserted when approved. This will save the PWS from having to make additional copies of the wellhead delineation and contaminant source inventories to put in the wellhead protection plan. The PWS should keep in mind that there will be a minimum total of 5 necessary -- one for the PWS, two for the Division of Water Supply (one will be sent to the Environmental Assistance Center) and two copies for local government (county government and planning commission).

The review and approval process by the Division of Water Supply is anticipated to take three months. If the review process takes longer than three months, the PWS will be notified in writing of the delay and such delay will accounted for in the timeframe for subsequent submittals by the PWS.

2.4.3 Wellhead Protection Procedures List

For convenience and clarity, a Wellhead Protection Regulation basic procedures/milestones list for the individual categories is included in the following tables:

Table 2.4.3A
Procedures List
Category 1 PWS
{All Noncommunity PWS}
{Community PWS w/ < 100 Connections}
{& <20,000 gpd production}

1) Send letter to county government officials by May 6, 1994 (Example letter in Appendix 10).

2) Obtain a 7 1/2 minute topographic map of your area from the Tennessee Division of Geology (see contacts list in Table 4 in Appendix). **Current plans are for the Division of Water Supply to mail Category 1 PWS the appropriate map.**

3) Locate and mark PWS wells and springs on topographic map (make photocopy for working map, also acceptable for submittals).

4) Draw 250 foot radius (Zone 1) and 750 foot radius (Zone 2) around each PWS well and spring on working map. It would be best to make an enlarged copy of the map for this (approximately 2X) -- pay attention to scale and mark "blow up" scale on the copy.

5) Contact local fire department/volunteer fire department (if there is one), County Agriculture Agent, County Soil Conservation Service about chemicals and pesticide use in your wellhead protection area (see Sections 3.3 - 3.5). This information must be included in the Contaminant Source Inventory. In the absence of a local fire department, the PWS can contact the Division of Water Supply with the names of the facilities within the wellhead protection area and the Division will work to obtain the Community-Right-To-Know information.

6) Use the Potential Contaminant Source Inventory List in Appendix 9 to characterize your Wellhead Protection area.

7) Take photographs around your wells and springs as specified in Regulations (compass directions N,NE,E,SE,S,SW,W,NW).

8) Prepare written Plan (see Appendix 11) on how you will protect your wellhead protection area from potential sources of contamination inventoried previously. You should concentrate particularly on Zone 1 -- chemical storage on your property, chemical use within Zones 1 and 2 (for example, notification of landowners within the zones, written agreement with adjacent landowners) and contingency planning (including spill response -- contacts with TEMA and Division of Water Supply). Placing a sign in your wellhead protection area is optional.

Table 2.4.3A (continued)
Procedures List
Category 1 PWS

9) Send in two copies of the Wellhead Protection Plan to the Division of Water Supply, one to the address previously specified and the other to the appropriate Water Supply Environmental Assistance Center by no later than March 1, 1995 for Community Systems and September 1, 1995 for Noncommunity Systems. The Plan must include a map with wells and springs labeled and marked, Zones 1 and 2, potential contaminant sources list keyed to map (see Appendix 9), and management plan.

10) Once the plan has been approved in writing, send a copy to county government officials.

Table 2.4.3B
Procedures List
Category 2 PWS
{Community PWS 100 - 999 Connections}
{& <315,000 gpd production}
{Community PWS w/ < 100 Connections}
{& 20,000 - 314,999 gpd production}

1) Send letter to county & municipal government officials by May 6, 1994 (Example letter as Appendix 10).

2) Obtain a 7 1/2 minute topographic map of your area from the Tennessee Division of Geology (see contacts list in Table 4 in Appendix). Current plans are for the Division of Water Supply to mail Category 2 PWS the appropriate map.

3) Locate and mark PWS wells and springs on topographic map (make photocopy for working map, also acceptable for submittals). It is recommended that the wells be surveyed in or located using global positioning systems (equipment which takes satellite readings to accurately determine locations). It would be best to make an enlarged copy of the map for this (approximately 2X) -- pay attention to scale and mark "blow up" scale on the copy.

4) Draw 500 foot radius (Zone 1) around each PWS well and spring on working map. Estimate "working area" from a radius of 1/2 to 3/4 mile which lie uphill (higher elevation) from the PWS wells and springs. For those PWS in Middle and East Tennessee, see Section 3.4.2 for minimum area to consider.

5) Locate private wells and springs in the working area, any well logs, pump tests (West Tennessee) available on PWS wells and any sinkholes in the area (Middle and East Tennessee).

6) Take water level measurements from wells in area and determine elevation of water level by placing on topographic map. Determine elevations of springs, rivers and streams from topographic map (field locate springs and sinkholes -- topo maps don't show many of them).

7) Construct water level elevation map or request assistance from the Division of Water Supply and turn this information in for support from the Division. A water level map (also called "potentiometric surface map) has contour lines at 5, 10 or 20 foot elevation intervals to represent the ground water elevation across an area estimated from known water level elevation points for wells and springs (see Figure 2.0A). Request for assistance and data gathering must be by July 1, 1995.

8) Model (West Tennessee: Section 3.3) or define by hydrogeologic mapping (Middle and East Tennessee: Section 3.4) Zone 2 of Wellhead Protection Area (Division can assist on this, if requested).

9) Submit wellhead delineation to the Division of Water Supply by July 1, 1996.

10) Contact appropriate Department of Environment and Conservation Environmental Assistance Center to ask if there have been ground water violations, reports of ground water contamination within your wellhead protection area (see Section 4.5). Contact the local fire department/volunteer fire department (if there is one), County Agriculture Agent, County Soil Conservation Service about chemicals and pesticide use in you wellhead protection area (see Sections 3.3 - 3.5). This information must be included in the Contaminant Source Inventory. In the absence of a local fire department, the PWS can contact the Division of Water Supply with the names of the facilities within the wellhead protection area and the Division will work to obtain the Community-Right-To-Know information.

11) Use the Potential Contaminant Source Inventory List in Appendix 9 to characterize your Wellhead Protection area.

12) Take photographs around your wells and springs as specified in Regulations (compass directions N,NE,E,SE,S,SW,W,NW).

13) Submit Contaminant Source Inventory (keyed to map -- see Appendix 9) and photographs to the Division of Water Supply by February 1, 1997.

14) Contact county and local government (municipal) officials regarding support of the Wellhead Protection Program (required in the Wellhead Protection Regulations).

Table 2.4.3B (Continued)
Procedures List
Category 2 PWS

15) Prepare written Plan (see Appendix 11) on how you will protect your wellhead protection area from potential sources of contamination inventoried previously. Must include plans for chemical storage on property, hazardous chemical use within Zones 1 and 2, spill response within Zone 1 (contacts with TEMA and Division of Water Supply) and contingency planning, as well as informing and requesting the support of the local planning commission and county government for possible protective measures (see Section 4.0). The plan must also include procedures for updating and for public notification (newspaper as a minimum -- see Section 7.0).

16) Send in two copies of the Wellhead Protection Plan to the Division of Water Supply, one to the address previously specified and one to the appropriate Water Supply Environmental Assistance Center by no later than September 1, 1997.

17) Once plan has been approved in writing by the Division of Water Supply, send a copy to the county/municipal government officials.

Table 2.4.3C
Procedures List
Category 3 PWS
{Community PWS w/ 1000 - 2999 Connections}
{& < 1,000,000 gpd production}
{Community PWS w/ < 1,000 Connections}
{& 315,000 - 999,999 gpd production}

1) Send letter to county & municipal government officials by May 5, 1994 (Example letter in Appendix as Table 10).

2) Obtain a 7 1/2 minute topographic map of your area from the Tennessee Division of Geology (see contacts list in Table 4 in Appendix).

3) Locate and mark PWS wells and springs on topographic map (make photocopy for working map, also acceptable for submittals). It is recommended that the wells be surveyed in or located using global positioning systems (equipment which takes satellite readings to accurately determine locations). It would be best to make an enlarged copy of the map for this (approximately 2X) -- pay attention to scale and mark "blow up" scale on the copy.

4) Draw 750 foot radius (Zone 1) around each PWS well and spring on working map. Estimate "working area" from a radius of 1/2 to 3/4 mile which lie uphill (higher elevation) from

the PWS wells and springs. For those PWS in Middle and East Tennessee, see Section 3.4.2 for minimum area to consider.

5) Locate private wells and springs in the working area, any well logs, pump tests (West Tennessee) available on PWS wells and any sinkholes in the area (Middle and East Tennessee).

6) Take water level measurements from wells in area and determine elevation of water level by placing on topographic map. Determine elevations of springs, rivers and streams from topographic map (field locate springs and sinkholes -- topo maps don't show many of them).

7) Construct water level map (see Section 2.1, Table 2.4.2C).

8) Model (West Tennessee) or define by hydrogeologic mapping (Middle and East Tennessee) Zone 2 of Wellhead Protection Area.

9) Submit wellhead delineation to the Division of Water Supply by March 1, 1995.

10) Contact appropriate Department of Environment and Conservation Environmental Assistance Center to ask if there have been ground water violations, reports of ground water contamination within your wellhead protection area (see Section 4.5), local fire department, County Agriculture Agent, County Soil Conservation Service about chemicals and pesticide use in you wellhead protection area (see Sections 3.3 - 3.5). This information must be included in the Contaminant Source Inventory.

11) Potential Contaminant Source Inventory List in Appendix 9 may be used as a starting point to characterize your Wellhead Protection area. However, you should make use of EPA Guidance on Conducting Contaminant Source Inventories. The EPA Guidance will be distributed by the Division to Category 3 & 4 PWS with the document you are now reading.

12) Take photographs around your wells and springs as specified in Regulations (compass directions N,NE,E,SE,S,SW,W,NW). Obtain aerial photographs from local Agricultural Stabilization Conservation Service (ASCS) or other source.

13) Submit Contaminant Source Inventory (keyed to map -- see Appendix 11) and photographs to the Division of Water Supply by November 1, 1995.

14) Contact county and local government (municipal) officials regarding support of the Wellhead Protection Program (required in the Wellhead Protection Regulations).

Table 2.4.3C (Continued)
Procedures List
Category 3 PWS

15) Prepare written Plan (see Appendix 11 for basic concept, Category 3 and 4 will require additional detail) on how you will protect your wellhead protection area from potential sources of contamination inventoried previously. Must include plans for chemical storage on property, hazardous chemical use within Zones 1 and 2, spill response within Zone 1 (contacts with TEMA and Division of Water Supply) and contingency planning, as well as informing and requesting the support of the local planning commission and county government for possible protective measures (see Section 4.0). The plan must also include procedures for updating and for public notification (newspaper as a minimum -- see Section 7.0).

16) Send in two copies of the Wellhead Protection Plan to the Division of Water Supply, one to the address previously specified and one to the appropriate Environmental Assistance Center by no later than January 1, 1997.

17) Once plan has been approved in writing by the Division of Water Supply, send copy to county/municipal government officials.

Table 2.4.3D
Procedures List
Category 4 PWS
{Community PWS w/ > 3,000 Connections}
{Community PWS w/ < 3,000 Connections}
{& 1,000,000 gpd or greater production}

1) Send letter to county & municipal government officials by May 5, 1994 (Example letter in Appendix as Table 10).

2) Obtain a 7 1/2 minute topographic map of your area from the Tennessee Division of Geology (see contacts list in Table 4 in Appendix).

3) Locate and mark PWS wells and springs on topographic map (make photocopy for working map, also acceptable for submittals). It is recommended that the wells be surveyed in or located using global positioning systems (equipment which takes satellite readings to accurately determine locations). It would be best to make an enlarged copy of the map for this (approximately 2X) -- pay attention to scale and mark "blow up" scale on the copy.

4) Draw 750 foot radius (Zone 1) around each PWS well and spring on working map. Estimate "working area" from a radius of 1/2 to 3/4 mile which lie uphill (higher elevation) from

the PWS wells and springs. For those PWS in Middle and East Tennessee, see Section 3.4.2 for minimum area to consider.

5) Category 4 Middle and East Tennessee PWS need to obtain the services of a private consultant or other agency to perform dye tracing to include in the hydrogeologic mapping.

6) Locate private wells and springs in the working area, any well logs, pump tests (West Tennessee) available on PWS wells and any sinkholes in the area (Middle and East Tennessee).

7) Take water level measurements from wells in area and determine elevation of water level by placing on topographic map. Determine elevations of springs, rivers and streams from topographic map (field locate springs and sinkholes -- topo maps don't show many of them).

8) Construct water level map (see Section 2.1 and Table 2.4.2C).

9) Model (West Tennessee) or define by hydrogeologic mapping (Middle and East Tennessee) Zone 2 of Wellhead Protection Area.

10) Submit wellhead delineation to the Division of Water Supply by May 1, 1995.

11) Contact appropriate Department of Environment and Conservation Environmental Assistance Center to ask if there have been ground water violations, reports of ground water contamination within your wellhead protection area (see Section 4.5), local fire department, County Agriculture Agent, County Soil Conservation Service about chemicals and pesticide use in you wellhead protection area (see Sections 3.3 - 3.5). This information must be included in the Contaminant Source Inventory.

12) Potential Contaminant Source Inventory List in Appendix 9 may be used as a starting point to characterize your Wellhead Protection area. However, should make use of EPA Guidance on Conducting Contaminant Source Inventories. The EPA Guidance will be distributed by the Division to Category 3 & 4 PWS with the document you are now reading.

13) Take photographs around your wells and springs as specified in Regulations (compass directions N,NE,E,SE,S,SW,W,NW). Obtain aerial photographs from local Agricultural Stabilization Conservation Service (ASCS) or other source.

14) Submit Contaminant Source Inventory (keyed to map -- see Appendix 11) and photographs to the Division of Water Supply by January 1, 1996.

15) Contact county and local government (municipal) officials regarding support of the Wellhead Protection Program (required in the Wellhead Protection Regulations).

Table 2.4.3D (Continued)
Procedures List
Category 4 PWS

16) Prepare written Plan (see Appendix 11 for basic concept, Category 3 and 4 will require additional detail) on how you will protect your wellhead protection area from potential sources of contaminiation inventoried previously. Must include plans for chemical storage on property, hazardous chemical use within Zones 1 and 2, spill response within Zone 1 (contacts with TEMA and Division of Water Supply) and contingency planning, as well as informing and requesting the support of the local planning commission and county government for possible protective measures (see Section 4.0). The plan must also include procedures for updating and for public notification (newspaper as a minimum -- see Section 7.0).

17) Send in two copies of the Wellhead Protection Plan to the Division of Water Supply, one to the address previously specified and one to the appropriate Water Supply Environmental Assistance Center by no later than March 1, 1997.

18) Once plan has been approved in writing by the Division of Water Supply, send copy to county/municipal government officials.

2.4.4 Timeframe Extensions

Owing to the wide variety of PWS and the sometimes complex nature of Wellhead Protection Program development, the Department recognizes that there may be extenuating circumstances which keep the PWS from completing their Wellhead Protection Program within the required timeframe. Consequently, extensions are provided for in the Wellhead Protection Regulations. A PWS may apply to the State for an extension of the time frame to submit the wellhead protection plan to the State. The request must be in writing and describe the basis for the request. A system must provide the following information and data to the Department with a request for an extension: (1) number of wells; (2) size of the wellfield; (3) size of Zone 1 and 2 (Zone 2 may not be completed); (4) technical data; (5) steps and procedures the PWS has implemented to achieve compliance with these rules; and (6) any other information required by the State. The term of the extension shall be set by the Department, however, the term of the extension shall not exceed three (3) years. A system may request, in writing, that the extension be continued for an additional three (3) years for good cause. The Department shall review and, where appropriate, revise its determination when relevant data or information becomes available.

3.0 Guidelines for Delineating Wellhead Protection Areas

Several methods exist for delineating wellhead protection areas. These range in complexity and cost of implementation. The choice of delineation method depends on factors such as available resources, hydrogeologic conditions, and the specific goals and objectives set by the PWS and local government that may be beyond the minimum regulatory requirements. Most of the more sophisticated techniques involve analytical methods and/or computer modeling.[1]

3.1 <u>Tennessee's Selection of Delineation Methods</u>

Tennessee's Wellhead Protection Regulations use a combination of a fixed radius for the innermost zone immediately around the well or spring (Zone 1) and an outer long term protection zone (Zone 2) delineated on the basis of ground water flow direction and other hydrogeologic factors. The delineated wellhead protection areas must be submitted for Division of Water Supply approval prior to proceeding to the contaminant source inventories to be discussed in the Section 4.

3.2 <u>Arbitrary Fixed Radius</u>

The arbitrary fixed radius approach to wellhead protection involves drawing a circle of specified radius around each PWS well or spring to delineate the wellhead protection areas. Using the arbitrary fixed radius is an inexpensive, rapid, easily implemented method of wellhead delineation that requires little technical expertise. Many wells can be protected quickly using this approach. It is particularly useful where an imminent contamination threat exists that demands immediate attention.[1]

3.2.1 <u>Tennessee's Zone 1 Designation</u>

Tennessee's approach uses arbitrary radii set based on PWS size categories to delineate the innermost protection zone, referred to as the Wellhead Protection Zone, or Zone 1:

TABLE 3.2A
ZONE 1 RADII BY CATEGORY

(i) Category 1: 250 feet*

(ii) Category 2: 500 feet

(iii) Category 3: 750 feet

(iv) Category 4: 750 feet

*Category 1 for Zone 2 is also fixed at 750 ft.

The distances established for Zone 1 for all PWS categories as well as Zone 2 for Category 1 PWS were based on practical, manageable distances (see Categories in Table 2.4.1A and Fixed Radii in Table 3.2A) with certain technical considerations:

1) The 250 foot radius for the inner zone (Zone 1) on Category 1 PWS (<100 connections and <20,000 gpd) is supported by considerations from the Aquifer Recharge Area and Withdrawal Balance Formula (Section 3.4.2). The area for a 250 foot radius at 20,000 gallons per day figures in at approximately 5 weeks "recharge/withdrawal time" for annual aquifer recharge rates from 6 - 8 inches per year. For the WHPA model, an unconfined aquifer with withdrawal at 20,000 gpd and a hydraulic gradient from 0.005 - 0.01 with other typical West Tennessee parameters will have a 56 day (8 weeks) Time-of-Travel which is contained within a 250 foot radius of the well.

2) The 750 foot radius for the outer zone (Zone 2) Category 1 PWS relates to approximately 1 year "recharge/withdrawal time" for annual aquifer recharge rates from 6 - 8 inches per year. Similarly, for the WHPA model; an unconfined aquifer with withdrawal at 20,000 gpd and a hydraulic gradient from 0.0035 - 0.007 (values roughly equivalent to Jackson's wellfields) with other typical West Tennessee parameters a 750 foot radius will approximately encompass a one year Time-of-Travel. Tennessee's Wellhead Protection Regulations have a provision for expanding the Wellhead Protection area in cases where the protection is not considered adequate.

3) For Category 3 and 4 PWS, the 750 foot radius was based on WHPA model considerations, with a two million gallons per day (mgd) in a leaky confined aquifer setting. With values expected in the Memphis area, an eight week Time-of-Travel model will produce a zone as much as 600 feet in length. Similarly, an eight week Time-of-Travel model in an unconfined setting using figures from Jackson's two wellfields at 2 mgd, yields an area which would be encompassed by a 500 - 600 foot radius. West Tennessee Category 2 - 4 PWS are encouraged to modify Zone 1 to reflect 8 weeks Time-of-Travel.

4) The 500 foot fixed radius for Category 2 PWS was picked as halfway between the 250 foot radius and the 750 foot radius.

3.3 Modeling Techniques for West Tennessee

3.3.1 Analytical Modeling/WHPA 2.2

WHPA 2.2 is a modular semianalytical ground water flow model developed by U.S. EPA's Office of Ground Water Protection (currently the Office of Ground Water and Drinking Water) primarily to assist state and local technical staff with WHPA delineation. The WHPA model uses a computer program to solve the analytical equations for two-dimensional flow to a well under various hydrologic conditions. WHPA can be used on most personal computers and is very straightforward to use. The user is prompted through a series of pop-up windows, to provide the specific input required. Specific hydrogeologic input data are required to satisfy equations at each well where modeling is implemented. These data include ground water flow direction, hydraulic conductivity, transmissivity, hydraulic gradient (slope of the water table), pumping rate, and thickness of the aquifer (saturated zone). With this information, WHPA 2.2 can generate a map at a scale which can be transferred to a topographic work map or even a customized scale.[2,9] For further explanation on basic ground water hydrology the reader is referred to the USGS Paper: Basic Ground-Water Hydrology.[3]

Modeling of the WHPA 2.2 type is relatively inexpensive, even though consultants may be involved, and is one of the most extensively used methods for delineating wellhead protection areas. Costs escalate where site-specific hydrogeologic data are not readily available, and test holes must be drilled or pump tests must be performed.[2]

The advantages of using the WHPA model in wellhead delineation are that it determines ground water flow paths and travel times very precisely incorporates the effect of well interference, and provides rapid solution of analytical equations combined with delineation of the zone of contribution.[2,9]

The WHPA model contains four independent modules: RESSQC, MWCAP (Multiple Well Capture Zone), GPTRAC (General Particle Tracking), and MONTEC (Uncertainty Analysis). These modules compute the zone of contribution of wells based on a range of input data. Each module operates completely independently of one another. For purposes of Tennessee's Wellhead Protection Program, the allowable modules are RESSQC for unconfined aquifers and GPTRAC or MONTEC for leaky confined aquifers. Each module is discussed in detail in the EPA guidance manual accompanying WHPA 2.2.

3.3.2 Numerical Models/MODFLOW

Numerical modeling utilizes computer modeling techniques to simulate the three-dimensional boundaries of an aquifer using numerical equations to produce a mathematical flow model.[2] Perhaps the best known numerical model is the U. S. Geological Survey's MODFLOW.

In general, the numerical approach requires the formulation of a grid that simulates the test aquifer. At each node, values such as water table elevation, hydraulic conductivity, and aquifer thickness are input. These form the basis for a matrix of equations that simulate the aquifer. The model can simulate changes in any of the hydrologic conditions characterizing the aquifer to investigate the effects of such alterations.

The main advantage of these numerical computer models such as MODFLOW is their ability to model aquifers exhibiting complex hydrogeology. This requires a significant amount of field information because the data input usually covers a wide range of hydrogeologic parameters. A major advantage of computer modeling is the rate at which computers can synthesize and manipulate large amounts of analytical data. An additional advantage is the predictive nature of modeling techniques, which allows the user to determine the system's response to a variety of proposed management options. In addition to these useful predictions, these models provide a high degree of accuracy.[2]

Because computer and hydrogeological expertise is needed to produce these numerical models, this method can be costly. It has the potential to be the most expensive of all the delineation methods. If a high degree of accuracy is demanded, however, this methodology can prove cost-effective, especially if a large, detailed data base is available from which to work. For a more extensive discussion of numerical modeling techniques, see Model Assessment for Delineating Wellhead Protection Areas.[2]

3.3.3 Tennessee's Zone 2 Delineation by Modeling

The relatively homogeneous occurrences of ground water in the West Tennessee granular (sand) aquifers (Figure 2.1C) lend themselves to the use of analytical modeling. This involves the use of representative hydrogeological information, time of travel (TOT), and flow boundaries (location of physical or hydrologic features controlling ground water flow). For consistency, Tennessee has designated two models as acceptable in the delineation of wellhead protection areas: EPA's WHPA 2.0 (or its slightly improved update, WHPA 2.2) and the U.S. Geological Survey's MODFLOW. Other models are allowed, but will be reviewed and approved on a case-by-case basis. Use of these two public domain models is strongly recommended in that they are widely used and accepted. Other models may require extensive proof of acceptability. Should other EPA-approved models become available, they should be considered as well.

Appendix 1 contains an alphabetical listing of Community Public Water Systems which gives the PWS information regarding geology (confined vs. unconfined) and other pertinent information. Public Water Systems are encouraged to use withdrawal figures that reflect the capacity of the production system rather than average daily production rates. This will minimize the required updates to the Wellhead Protection Plans where increases in production rates occur.

Tennessee is using the area delineated by 10 Year Time of Travel modeling as a minimum for delineating the ground water contribution area for the longer term outer zone (Wellhead Management Zone or Zone 2). This would not preclude a PWS and local government from developing Zone 2 delineated using 15 or 20 year Time of Travel.

In that the data for determining 10 Year TOT will work with very little effort for longer TOT's and can easily be done for shorter TOT's, the PWS are encouraged to run 5, 15 and 20 Year TOT's for their own information. If a PWS wishes to include beyond 10 year TOT, the PWS may wish to consider adding a third zone of protection. Tennessee's Regulations also do not preclude a PWS from dividing Zone 2 into more than one "subzone", such as Zone 2A at five year TOT and 2B at ten year TOT.

PWS are encouraged to convert the Wellhead Protection Zone (Zone 1) from an arbitrary fixed radius to one based on an 8 week TOT. The eight week TOT is considered to be the minimum timeframe to allow for immediate threats in the vicinity of a PWS well to have some form of remedial action taken prior to contamination reaching the well. Eight weeks TOT also allows for less persistent chemicals to degrade prior to reaching the well and offers some protection from pathogens (viruses and bacteria) as well.[1]

Tennessee's Wellhead Protection Regulations consider all confined aquifers as leaking. This is a reasonable assumption for the Memphis Sand with a number of windows in the confining layer. On the surface this would not appear appropriate for PWS using the deeper Fort Pillow Sand aquifer; however, GPTRAC and MONTEC both require hydraulic conductivity and thickness of the confining layer which serves to offset this issue in the modeling scenarios that have been tested. In addition, a fully confined aquifer would actually require a larger wellhead management area. PWS using the Fort Pillow Sand may wish to consider somewhat different management options, such as focusing on the use of denser chemicals that have the capability of penetrating/breaking down the confining layer.

The PWS may wish to hire a consultant to do the delineation part of the Wellhead Protection Program. See Section 3.6 for tips on hiring a consultant taken from EPA's Wellhead Protection Guide for Small Communities.[9] The Guide for Small Communities is very useful for a variety of wellhead protection issues and is strongly recommended (Appendix 4 has information on ordering). Community PWS will be mailed a copy of EPA's Guide for Small Communities with this Guidance Document.

In addition to typical consultants, the Ground Water Institute at Memphis State University or the U.S. Geological Survey (addresses in Appendix 4) can provide similar services and both specialize in aquifer modeling. There may be a concern with Meeting the strict deadlines required for Tennessee's Wellhead Protection Program may be a concern with university staff or the USGS. The USGS also has several useful ground water publications for West Tennessee. The Category 2 PWS have the option of obtaining the preliminary field information (water levels and PWS well information) and requesting assistance from the Division of Water Supply.

3.3.4 <u>Information Needs for Modeling</u>

It is anticipated that most PWS will opt for WHPA 2.2 since this model is considerably less complex and requires less data than MODFLOW. Table 3.3.4A provides a comparison of the two models. The Ground Water Institute at Memphis State University has done a comparative study between WHPA 2.0 and MODFLOW for one Memphis wellfield as a part of an EPA Wellhead Protection Demonstration Grant which indicates that within the 10 Year Time of Travel required by Tennessee's Regulations, there is little appreciable difference (1993, Personal Communication with Dr. John Smith, Memphis State Ground Water Institute). WHPA 2.2 is the recent update to WHPA 2.0. WHPA 2.2 is distributed by the International Ground Water Modeling Agency (303-273-3103). Contact this agency for the most recent version.

Table 3.3.4A*
Comparison of WHPA and MODFLOW

Parameter	WHPA	MODFLOW	Comments
Type Model	2 Dimension	3 Dimension	
Starting Heads Required	No	Yes	
Steady State Case	Yes	Yes	
Transient Case	No	Yes	
Vertical Hydraulic Conductivity	Yes	Yes	VHC is used in calculating conductance
Transmissivity	Yes	Yes	
Multilayered	No	Yes	MODFLOW can model layers explicitly.
Aquifer Thickness	Yes	Yes	
Screen Over Length of Aquifer	Yes	Yes	
Confining Bed Thickness	Yes	Yes	
Hydraulic Gradient	Yes		Calculated internally by MODFLOW
Porosity	Yes	Yes	
Number of Wells	50	Unlimited	

***Table Contributed by Memphis Light, Gas and Water; Jan. 1994**

PWS are encouraged to collect as much area-specific data as they feasibly can, however, the Division of Water Supply has derived some acceptable default values from the USGS Basic Ground Water Hydrology publication (Appendix 5A and 5B) for aquifer hydraulic conductivity (10) and porosity (0.20) and work with WHPA 2.2. Accurate ground water flow direction, hydraulic gradient and pumping rate are critical in that they have the most significant effects on the WHPA model.

The hydraulic conductivity to provide the yield necessary for a PWS well will have to be 10 or more and 10 appears to be a good average from work with WHPA. A porosity of 20% is a good working average - a change 2 - 3% higher or lower makes very little difference in the model.

Modeling requires the construction of a water-table map from collected water level data (Appendix 3 contains EPA's water level measurement protocol), although not necessarily in the detail required with other techniques. It is recommended that at least a few locations be surveyed in as control points to more accurately construct the water table or potentiometric surface map. Use of water elevations from hand dug wells is not recommended. Flow lines are drawn perpendicular to the water-table elevation lines. These flow lines begin at the well and extend upgradient to the ground-water divide. The water table map is necessary to determine both the slope of the water table (hydraulic gradient) and general ground water flow direction.

3.4 Hydrogeologic Mapping Delineation in Karst and Fractured Areas for Middle and East Tennessee

3.4.1 Karst Conditions

In unconfined or poorly confined conditions, karst aquifers can have very high flow (and contaminant transport) rates under rapid recharge conditions such as storm events. Solution enhancement of bedding plane joints and fractures in karst aquifers creates large pathways. As a result, flow velocities in karst aquifers having conduit flow can range over several orders of magnitude between high-flow and normal-flow conditions. Owing to the necessary high flow volume required for PWS operations, most PWS karst wells and springs are in conduit flow conditions.

Transport times across entire karst flow systems may be as short as hours to weeks, much briefer than in porous, granular aquifers. For this reason, these susceptible aquifers must be evaluated differently than the more common porous, granular (sand) aquifers.

3.4.2 Hydrogeologic Mapping

Hydrogeologic mapping for delineation in karst and fracture-controlled aquifers makes use of geological and geomorphic techniques for flow boundary and vulnerability mapping, with the addition of dye tracing methods for conduit-flow karst. To determine appropriate flow boundaries, geological studies of the aquifer are undertaken to identify varying rock characteristics which indicate permeable and non-permeable rock material. Ground water drainage divides also can be used in hydrogeologic mapping.[1,9]

Flow boundary mapping delineation works well for aquifers whose flow boundaries are relatively near the surface, as found in glacial and alluvial aquifers, and for aquifers exhibiting different physical properties in different directions, as found in fractured bedrock and channeled karst.[1,9] For karst aquifers, this needs to be followed by dye-trace testing to produce more accurate mapping of the karst recharge patterns. **Dye tracing is essential in karst aquifers because ground water flow patterns commonly do not follow topographic divides and can change significantly depending on whether high- or low-flow conditions exist.**

The flow boundary mapping approach essentially delineates wellhead protection areas based on boundaries of the Zone of Contribution (ZOC) being inferred as the divides or drainage boundaries of the setting, similar to surface water drainage basins and divides (see Figure 2.1D). Examples of surface features that in some settings act as flow boundaries are topographic features such as ridges and hydrologic features such as rivers, canals and lakes. Structural features such as faults, folds, zones of fracturing, bedding plane orientation and geologic contacts that form the limits of the aquifer may also be important in assessing ground water flow.

Flow boundary mapping requires detailed mapping of the configuration of the water table. Ideally, investigators should use field measurements in properly constructed monitoring wells and nested piezometers for construction of such maps. It is recommended that at least a few locations be surveyed in as control points to more accurately construct the water table or potentiometric surface map. In practice, funding and time considerations can rule out such detailed field work. In some situations, available office data, in the form of water levels on well constructors' reports, previous hydrogeologic studies, and surface-water features on topographic maps, can produce acceptable water-table maps. Field measurements of water levels in existing domestic and industrial wells and springs can supplement these data.[1] The wellhead protection area can then be delineated by developing catchment area (drainage divides) mapping and water table mapping. If time and resources allow, water table elevations for wells and springs should be collected under normal and high-flow conditions to determine general ground water flow directions in that flow directions can change from high to low flow periods.

Caution is required when using flow boundary mapping in karst systems. It is a reasonable first approximation; however, in conduit flow conditions, ground water flow can cross surface flow boundaries. This is the reason dye traces are recommended -- flow can actually run beneath rivers to springs on the opposite side.

Using the flow boundary technique, once a water-table map is constructed, flow lines are drawn perpendicular to the water-table elevation lines (for EPA protocol on taking water level measurements see Appendix 3). These flow lines begin at the well and extend upgradient to the ground-water divide. Using a water-table map to determine ground-water flow lines assumes an isotropic aquifer, which is not truly the case in karst and fractured-rock settings. In simple hydrogeologic settings (without faults, facies changes, etc.), the ZOC delineated by the flow-system mapping method takes into account the ground-water flow system geometry and does generally give some indication of general ground water flow direction. In more complex settings, more detailed hydrogeological study and dye tracing is required to accurately determine the ground water system.

Vulnerability mapping uses geologic maps, soils maps, water-table maps, aerial photographs (to identify fracture traces), and mapping of surficial features such as jointing patterns and shallow and exposed bedrock to identify areas of the landscape particularly vulnerable to ground-water contamination. Vulnerability mapping alone does not produce a ZOC for a given well; however, it does identify significant features near the well that may contribute to ground-water contamination. Using vulnerability mapping in combination with flow boundary mapping, the ZOC of a well or spring is addressed.

Particularly important in vulnerability mapping in karst is the field identification of upgradient (higher elevation) features such as springs, sinkholes (particularly open-throated sinkholes), open fractures and losing or disappearing streams from the well or spring that can provide a direct conduit to the ground water. Identifying these critical features is probably best left to an expert in karst hydrology, as unexperienced professionals could overlook key features. Both the springs and sinkholes give a "window" into the aquifer -- the spring elevations are easily obtainable water level measurements and dye trace check points. The sinkholes provide an avenue for recharge and can be used for dye trace injection. For further discussion of karst and dye trace techniques, the reader is referred to Application of Dye-Tracing Techniques for Determining Solute-Transport Characteristics of Ground Water in Karst Terranes.[5]

3.4.3 Aquifers in Middle and East Tennessee

The Middle and East Tennessee aquifers are predominantly in karst with some fractured rock terrain in the Cumberland Plateau and upper east (northeast) Tennessee (see Figure 2.1C and 2.1D). Appendix 1 gives the geologic setting for the individual PWS. Inhomogeneous, anisotropic aquifers such as these have highly directional and sometimes turbulent flow conditions which do not meet the homogenous, isotropic, laminar flow assumptions required to realistically model in the manner of the West Tennessee sand aquifers. For this reason, Tennessee has taken a different approach in the delineation of wellhead protection areas for Middle and East Tennessee.

Tennessee is using a combination of flow boundary mapping and vulnerability mapping to delineate the Wellhead Management Zones for Middle and East Tennessee.

In the steeply dipping rocks of the Valley and Ridge Province of East Tennessee the reader should be aware that ground water flow will frequently be along strike (parallel to the long axis of the ridge) rather than along the dip (downslope) of the beds. At locations where there is cross-strike fracturing there can still be extensive cross-strike ground water flow.

3.4.4 Aquifer Recharge Area & Withdrawal Balance

As a part of this Guidance Document, an Aquifer Recharge & Area of Withdrawal Balance Formula (ARAWB) is used to assist PWS in delineating wellhead protection areas in karst and fractured bedrock aquifers. The formula is intended to assist the PWS by giving them a tangible minimum area guideline in designating their Wellhead Management Zones using the flow boundary and vulnerability mapping techniques. The Aquifer Recharge & Area of Withdrawal Balance Formula (ARAWB) is as follows:

$$A = Q/R_c$$

Where A = Area of recharge in square feet
Q = Withdrawal (Pumping rate) of well or total discharge of spring (ft3 per year)
R_c = annual recharge, feet per year
(must convert from inches per year)

This formula is a derivation of a formula for the radius around a well which relates aquifer recharge to pumping rate. This has been used by the USGS (USGS written communication, 1992) and by North and South Carolina in delineating their wellhead protection areas.[10] The formula relates the amount of surface area needed for the aquifer recharge in that locality to supply the amount of water withdrawn/discharged from a well or spring.

The formula used by the USGS and North and South Carolina is as follows:

$$Q = \pi r^2 R_c$$

Where Q = Withdrawal (Pumping rate) of well (ft3 per year)
r = radius of influence in feet
R_c = median annual recharge, feet per year
(must convert from inches per year)

The lowest annual aquifer recharge rates for the five major geographic areas in Middle and East Tennessee are:[6]

Highland Rim	4.9 inches (.41 ft) per year
Central Basin	4.1 inches (.34 ft) per year
Cumberland Plateau	4.3 inches (.36 ft) per year
Valley and Ridge	5.2 inches (.43 ft) per year
Blue Ridge	8.0 inches (.67 ft) per year

Using the ARAWB formula, one can calculate the recharge area necessary to provide the amount of water withdrawn/discharged by a well or spring. For example, a for a PWS with a well producing 100,000 gallons per day in the Central Basin, the following calculation would be made:

$$A = Q/R_c$$

$$A = (100{,}000 \text{ gal/day})(.13368 \text{ ft3/gal})(365 \text{ days/yr})/(.34 \text{ ft/yr})$$

$$A = 14{,}350{,}941 \text{ ft}^2$$

(or 14,400,000 ft^2, when rounded to three significant digits)

Thus, this PWS would need to include at a minimum 14,400,000 ft^2 of the area upgradient of the well determined from flow boundary/ vulnerability mapping to be part of the wellhead protection area as its Wellhead Management Zone. If one prefers to think of this as acreage, the conversion factor is:

$$1 \text{ acre} = 43560 \text{ ft}^2$$

This would mean that this hypothetical PWS would have an area covering approximately 331 acres as a minimum to consider. Appendix 1 has been included giving the aquifer recharge value for the individual PWS. Where the PWS may lie on the border between two basins, an average of the two values was used.

The ARAWB formula calculates the area over which aquifer recharge is required to take place to meet the amount of ground water withdrawn. The formula is understandably simplistic, however, it does provide a minimum area to consider. The formula assumes a balance where the amount water withdrawn is equal to the water being recharged to the aquifer. The inherent assumption is that this is a dynamic system where the water being withdrawn is all coming from recharge infiltrating into the aquifer from within the recharge basin and there is negligible change in storage. For unconfined or leaky confined karst and fractured bedrock settings where rapid recharge occurs coming primarily from local sources, this is considered to be a reasonable assumption for a minimum area guideline. The lowest recharge value from the USGS recharge study[14] was used as the most conservative number.

For a PWS using a spring, the total discharge of the spring at high flow conditions must be considered in this calculation rather than the amount the PWS is withdrawing from the spring for its use. PWS on wells are encouraged to use withdrawal figures that reflect the capacity of the production system rather than average daily production rates. This will minimize the required updates to Wellhead Protection Plans where increases in production rates occur.

Detailed hydrogeologic mapping and dye tracing connections to the aquifer would be able to refine this preliminary estimation to determine those portions of the drainage basin that actually contribute to a well or spring. Dye tracing is strongly recommended for all PWS in karst settings and should in many cases reduce the size of the delineated Wellhead Management Area; however, dye tracing has only been required in regulation for the Category 4 PWS.

3.4.5 Dye Tracing Techniques

Tracing techniques can be used to map underground conduits by injecting dyes or tracers into a ground water system. The dye is introduced into a sinkhole or stream that flows into ground water suspected to flow to the supply source for which the WHPA is being delineated. Water from the supply well or spring is then monitored and/or observed for a period of time that is adequate for the tracer to reach the supply. If the tracer is detected in the supply, the source from which the tracer was injected becomes part of the wellhead protection area. It is commonly necessary to do more than one trace. It is critical that dye tracing be done by a trained professional with considerable experience in dye tracing.

Many materials have been used as water tracers. Fluorescent dyes (fluorscein and rhodamine WT) are well suited to the general needs of hydrologists. For further discussion of dye tracing, the reader is referred to EPA's Application of Dye-Tracing Techniques for Determining Solute Transport Characteristics of Ground Water in Karst Terranes[5] and the Water Tracers Cookbook.[7] EPA protocol on dye tracing techniques is available in Appendix 6.

The Wellhead Protection Regulations require Department notification and approval prior to conducting any dye trace which may impact a PWS. Notification and approval will be handled by the Division of Water Supply. For the dyes to be kept at low levels to minimize water quality effects, determinations must be made using "bugs" (charcoal or cotton absorption materials, depending on which dye is used) and then using an extracting solution to determine the presence of dye rather than relying on visual ("naked eye") detection over a limited time frame. The most accurate and strongly recommended method to use in dye tracing involves the use of a fluorometer or fluorospectrometer to determine more quantitative results and keep dye concentrations low.

Field identification of springs and sinkholes is critical in dye tracing. Identifying these critical features is probably best left to an expert in karst hydrology, as unexperienced professionals may overlook key features. It is important to identify and "bug" numerous area springs to determine ground water flow, not just the well or spring of concern. The springs identified can also be used to help construct the water table map, as discussed previously.

3.5 Information Requirements

The first step in delineation is establishing a base map for the area, giving detailed information on the natural features of the area and the location of all the public water supply wells and springs. Once a base map has been prepared, overlay maps can be drawn up outlining drainage basins, wetlands, ground water resources, sewer service areas, zoning districts, and land development plans. The base map should be at 1:24,000 (7 1/2 minute topographic map) or smaller scale (i.e., 1:12,000). Make sure you consider the scale of the maps when using more than one source.[9]

You can draw on many sources of data to prepare an overlay map of your community's hydrologic system. This system consists of drainage basins (watersheds), wetlands, and flood zones. The map can be prepared on clear film and then overlaid on the base map. Drainage basins or catchment areas collect water that might be ultimately transported into the aquifer. They are determined by finding the highest elevation points on your topographic map and connecting them by drawing boundary lines perpendicular to the surface contours. The resulting area will probably be much larger than your final wellhead protection area (and also may be a very different area).

You can obtain hydrogeologic information about your aquifer from an analysis of well logs, both public and private, and test boring logs. In addition to supplying geological information on the aquifer, well records show well discharge and water level fluctuations, which can be used to evaluate an aquifer's hydraulic conductivity, transmissivity, and storativity. Water table (or potentiometric surface) maps, if available, can also be helpful in wellhead protection delineation. These maps give information on the flow directions of ground water and its depth from the surface.

3.6 Technical Assistance

The geologic/hydrogeologic portion of the Wellhead Protection Program will in many cases require the services of an expert in the form of consultant, university staff (probably the lowest cost method, although level of expertise may be a concern) or the U.S. Geological Survey. For preliminary information and assistance, PWS may wish to contact the USGS or the geology department of one of the following state universities in their area:

University of Tennessee - Knoxville
Austin Peay University - Clarksville
Tennessee Technological University - Cookeville
East Tennessee State University - Johnson City
Middle Tennessee State University - Murfreesboro

The addresses for the USGS and the universities are given in Appendix 4. Category 2 PWS have the option of doing the initial field work (water level measurements, spring locations, etc.) and requesting assistance from the Division of Water Supply.

Selecting a consulting hydrogeologic firm to undertake a hydrogeologic study requires careful judgment. The firm's services can be expensive. If the delineated boundaries of your resource area should ever be challenged in court, it will be important to have chosen experienced professionals and have a well documented study. The possibility of needing assistance in a court challenge should be considered and discussed when selecting a consultant, particularly if using a government agency. The steps involved in choosing a consulting firm include identifying potential candidate firms, issuing a request for proposals, interviewing, checking references, and preparing a contract once a consultant has been selected.[9]

Potential candidates can be identified by the PWS's past experience, or by contacting your local extension service, the Tennessee Association of Utility Districts (part of the National Rural Water

Association -- see Appendix 4) or the Division of Water Supply. Tennessee Association of Utility Districts may also be able to offer technical support. The National Ground Water Association, the American Insitute of Hydrology, the American Institute of Professional Geologists, the National Society of Professional Engineers, and the American Academy of Environmental Engineers are good sources of consultant information. The National Ground Water Association also has training and literature available on ground water that may prove useful.[9]

A request for proposals will differ for PWS, depending on its size and the nature of the project. This document should be as specific as possible and should, at a minimum, describe the major goal of the project, the anticipated scope of work, and the final product(s) required (such as reports, ground water mapping, delineated wellhead protection areas or zoning map overlay) It should contain a request for information on personnel qualifications and experience, and should include standards by which the proposals will be judged. The wellhead protection planning team should compare the professional reputation of each firm, its experience in similar projects, including facilities and equipment capabilities, project cost and billing policy, understanding of the nature of the project, and the potential quality of the finished product.[9] **The PWS should focus particularly on the consultant's previous work in wellhead protection projects AND MAY WISH TO CONTACT PREVIOUS CLIENTS.**

For consultants doing geologic work, the PWS are advised to request their Tennessee registration number, as geologists operating in Tennessee are required to be registered with the Tennessee Department of Commerce and Insurance. Professional Engineers should provide proof of registration as well. Both should be asked to provide evidence that they are skilled in hydrogeological evaluations, particularly any wellhead protection studies.

Table 3.6A
Costs Associated with Various Wellhead Protection Area Delineation Methods

Method	Person-Hours Required per Well*	Level of Expertise[1]	Cost per Well	Potential Overhead Costs[2]
Arbitrary Fixed Radii	1 - 5	1	\$12 - 60	Low
Calculated Fixed Radii	1 - 10	2	\$17 - 170	Low
Analytical Methods	2 - 20	2	\$60 - 600	Medium
Hydrogeol. Mapping	4 - 40	3	\$20,000 - 60,000	Medium to High
Numerical Modeling	10 - 200+	4	\$350 - 7,000+	High

*The per well costs will be significantly reduced if there are additional wells in close proximity

[1]Hourly wages are assumed to be:

1. Non-technical — \$20
2. Junior Hydrogeologist/Geologist — \$45 - 60
3. Mid-Level Hydrogeologist/Modeler — \$60 - 80
4. Senior Hydrogeologist/Modeler — \$80 - 150

[2]Potential Overhead costs include those for equipment to collect hydrogeologic data, computer hardware and software, and the costs associated with report preparation. These figures do not reflect the costs for consulting firms potentially engaged in this work.

Source: Adapted from USEPA, 1987[9]

3.7 Wellhead Delineation Submittal

Category 2, 3 and 4 PWS are required to make a separate submittal of their delineated wellhead protection areas for Departmental approval within the schedule detailed previously. Two copies must be submitted to the Division of Water Supply, one to the address listed previously and one to the appropriate Environmental Assistance Center.

4.0 Guidelines for Performing Contaminant Source Inventories

In accordance with the Federal Safe Drinking Water Act Amendment provisions and Tennessee's Wellhead Protection Regulations, local wellhead protection plans must include an inventory of potential sources of contamination within the wellhead protection area (Zones 1 and 2) that may have an adverse effect on the ground water and public health.

An essential element in wellhead protection planning is conducting an inventory of all current, past, and future land uses which may pose a threat to the water supply. Well fields for small towns may be located in areas where residential, farming or park lands are the predominant land uses. More typically, lands around most wellfields contain several different land uses including agricultural uses and areas of residential, industrial and/or commercial development.

4.1 Potential Pollution Sources

Tennessee's urban population and diverse economy generate a wide variety of potential ground water contaminants. Tennessee's industries, commercial establishments and residences produce large quantities of solid wastes, hazardous wastes and wastewaters with the potential to contaminate the ground water. Additionally, modern agricultural practices involve the handling and application of large amounts and a wide range of fertilizers and pesticides. Other sources of potential contamination include underground storage tanks, septic tanks, road salt application, and miscellaneous leaks and spills from manufacturing processes and from small and large quantity hazardous waste generators.

The following table provides a general overview of sources and potential sources of ground water contamination:

Table 4.1A[8]

Sources of Ground-Water Contamination

Designed to Discharge

Septic tanks
Injection wells
- dry wells
- non-hazardous waste
- cooling waters
- stormwater runoff
- hazardous waste
- agricultural drainage
- automobile service station disposal
- industrial process water

Land application
- wastewater (spray irrigation)
- wastewater (sludge)
- hazardous waste
- Nonhazardous Waste
- petroleum refining waste

Designed to Retain Substances During Transport or Transmission

Pipelines
- hazardous, non-hazardous and non-waste; sewers

Materials transport and transfer Operations
- hazardous and nonhazardous

Designed to Store, Treat, and/or Dispose (Discharges through Unplanned Release)

Landfills
- industrial hazardous and nonhazardous
- municipal sanitary

Open dumps
Surface impoundments
- hazardous and nonhazardous

Waste tailings & piles
- hazardous and nonhazardous

Materials stockpiles
- hazardous waste
- Nonhazardous waste
- non-waste

Under and Aboveground storage tanks
- hazardous, nonhazardous, & non-waste

Containers
- hazardous, nonhazardous, & non-waste

Open burning sites
Detonation sites
Radioactive disposal sites

Table 4.1A (continued)[8] Sources of Ground Water Contamination

Providing Conduit or Inducing Discharge through Altered Flow Patterns	Discharging as Consequence of other Activities
Production wells	Irrigation practice
Oil and gas	Applications
Geothermal	Pesticide
Recovery	Fertilizer
	De-icing salts
Water Supply	Animal feedlot operations
	Urban runoff
drinking,	Mining and mine drainage
commercial or	Cemeteries
industrial	Spills and leaks from manufacturing operations

Many common (household) products in use can be a concern in subdivisions with a high density of septic tanks. Septic systems that are improperly sited, designed or constructed or maintained can contaminate ground water with bacteria, viruses, nitrates, detergents, oils, and chemicals.[19] Commercially available septic system cleaners containing synthetic organic chemicals (such as 1,1,1-trichloroethane or methylene chloride) have contaminated drinking water wells. Many chemicals should not be disposed of in household septic systems, including oils (e.g., cooking, motor), lawn and garden chemicals, paints and paint thinners, disinfectants, medicines, photographic chemicals, and swimming pool chemicals. It is a sobering fact to consider that 1 gallon of gasoline can render 1 million gallons of ground water nonpotable.[19] Table 4.1B gives a partial list of the potentially harmful components of common household products.[9] A lengthier listing of potential contaminant sources can be found in the Appendix as Table 7.

Table 4.1B[9]
Potentially Harmful Components of Common (Household) Products

Product	Toxic or Hazardous Components
Antifreeze (gasoline or coolant systems)	Methanol, ethylene glycol
Automatic transmission fluid	Petroleum distillates, xylene
Battery acid (electrolyte)	Sulfuric acid
Degreasers for driveways and garages	Petroleum solvents, alcohols, glycol ether
Degreasers for engines and metal	Chlorinated hydrocarbons, toluene, phenols, dichloroperchloroethylene
Engine and radiator flushes	Petroleum solvents, ketones, butanol, glycol ether
Hydraulic fluid (brake fluid)	Hydrocarbons, fluorocarbons
Motor oils and waste oils	Hydrocarbons
Gasoline and jet fuels	Hydrocarbons
Diesel fuel, kerosene, #2 heating oil	Hydrocarbons
Grease, lubes	Hydrocarbons
Rustproofers	Phenols, heavy metals
Car wash detergents	Alkyl benzene sulfonates
Car waxes and polishes	Petroleum distillates, hydrocarbons
Asphalt and roofing tar	Hydrocarbons
Paints, varnishes, stains and dyes	Heavy metals, toluene
Paint and lacquer thinner	Acetone, benzene, toluene, butyl acetate, methyl ketones
Paint and varnish removers, deglossers	Methylene chloride, toulene, acetone, xylene, ethanol, benzene, methanol
Paint brush cleaners	Hydrocarbons, toulene, acetone, methanol, glycol ethers, methyl ethyl ketones
Floor and furniture strippers	Xylene
Metal polishes	Petroleum distillates, isopropanol, petroleum naptha
Laundry soil and stain removers	Hydrocarbons, benzene, trichloroethylene, 1,1,1-trichloroethane
Other solvents	Acetone, benzene
Rock salt	Sodium concentration
Refrigerants	1,1,2-trichloro-1,2,2-trifluoroethane
Bug and tar removers	Xylene, petroleum distillates
Household cleansers, oven cleaners	Xylenols, glycol ethers, isopropanol
Drain cleaners	1,1,1-trichloroethane
Toilet cleaners	Xylene, sulfonates, chlorinated phenols
Cesspool cleaners	Tetrachloroethylene, dichlorobenzene, methylene chloride
Disinfectants	Cresol, xylenols
Pesticides (all types)	Naphthalene, phosphorous, xylene, chloroform, heavy metals, chlorinated hydrocarbons
Photochemicals	Phenols, sodium sulfite, cyanide, silver halide, potassium bromide
Printing ink	Heavy metals, phenol-formaldehyde
Wood preservatives (creosote)	Pentachlorophenols
Swimming pool chlorine	Sodium hypochlorite
Lye or caustic soda	Sodium hydroxide
Jewelry cleaners	Sodium cyanide

Source: "Natural Resource Facts: Household Hazardous Wastes," Fact Sheet No. 88-3, Dept. of Natural Science, University of Rhode Island, August 1988.

4.2 Developing an Inventory Team

For the intermediate to large PWS (Category 2, 3 and 4), it would be advisable to form a community planning team. The first characteristic of a successful community planning team is representation from diverse interests of the community. It may be possible to recruit local volunteers or organizations and local government officials to form a team to help with the inventory and further development of the plan. City building code inspectors, utility personnel (gas, electric and water) readers, county or regional planning commissions may already have useful information.[9] At this point, local government and the planning commission should already have been notified of the startup of the wellhead protection program, as required in the Wellhead Protection Regulations.

The planning team might include:

> Public organizations: community service organizations, environmental groups, public interest groups, League of Women Voters.
>
> Regulatory organizations: elected officials, local government agencies (health, planning, conservation, natural resources), public works director.
>
> Government/public service organizations: fire department, local cooperative extension agent, county Soil Conservation Service office. Fire departments can be of particular help because of the Community-Right-to-Know information that facilities are required to send them (see Section 3.4).
>
> Private organizations: businesses, farmers, land developers (The participation of commercial and business interests can enhance the effectiveness of the team's protection strategy during implementation stages).[9]

The PWS or planning team may wish to contact ACTION for help with Contaminant Source Inventories and Public Education. ACTION is a federal agency that coordinates the activities of volunteer organizations such as RSVP (Retired Senior Volunteer Program), VISTA (cost-sharing from state and federal) and Foster Grandparents. President Clinton has recently signed into law the National Service Act which, among other things, changes ACTION into the Corporation of National Community Service. RSVP is expanding into "non-traditional" areas related to environmental protection. RSVP and ACTION (contacts are in Appendix 4) have been helping in inventorying potential sources of contamination in delineated Wellhead Protection Areas (WHPAs) and in promoting the concepts of ground water protection through education and awareness.

If wellhead protection areas cross community lines, it is critical to develop inter-jurisdictional relationships. This ensures consistency in designated land use and planning restrictions. This interaction may involve the regional planning board, neighboring community boards, the agricultural extension service, and watershed associations.

Meetings of the planning team should be advertised in the local newspaper and public access channels/community service bulletin boards to attract as many concerned parties as possible and inform the public of the aims of the program.

4.2.1 Informing the Public

It is critical to continually inform the public of the progress in establishing a wellhead protection program. The success will depend a great deal on public support for the program. Mailings, advertisements, flyers, and community meetings are low cost techniques for reaching a broad spectrum of the community. Questionnaires can both provide information on the program and help the team gather information on ground water issues, particularly in regard to sources of contamination.[9] For further discussion on Public Education, see Section 7.0.

4.3 Inventory Procedures

Inventories should be kept separately for Zone 1 and 2 in a table format and keyed to a topographic map or map of smaller scale (more detail). For a detailed discussion on performing potential contaminant source inventories, the reader is referred to EPA's Guide For Conducting Contaminant Source Inventories For Public Drinking Water Supplies.[8]

At this point, maps will already have been obtained for the wellhead delineation of the Wellhead Protection Program. Initial inventory efforts should include acquisition of a suitable base map if the map used in delineating the area is not a sufficient scale and conducting windshield surveys to identify buildings and other physical features. A working map of the area should be on a scale of one inch equals 2000 feet or larger, and should include the delineated wellhead protection area as well as some of the surrounding lands outside the protection area. A 7-1/2 minute USGS topographic map (or an enlargement of same) is a preferred base map for recording pollution source information. Other maps which can be useful sources of information are those which depict zoning districts, geology, drainage, sewers and water distribution lines, mining activities, property owner boundaries and current political subdivision boundaries. Aerial photographs of the area can be valuable in identifying historical land uses and land use changes.[9]

Other maps that might prove useful when determining potential contamination sources and land management techniques include community tax assessor's maps, community zoning maps, community master development plan, maps of reserved/conservation lands and waters, and roadway and utility maps.

The PWS may wish to give prior notification to residents, businesses and property owners within the wellhead protection area at this stage. This can be a valuable public relations tool and can go a long way toward building support and cooperation regarding future wellhead protection efforts. Most industries and businesses are willing to cooperate with local officials involved in inventory efforts particularly if they have been informed ahead of time as to the overall purpose of the inventory and the long term benefits of wellhead protection planning and a safe water supply.

Methods for informing individuals about wellhead protection include public meetings, workshops, brochures, news letters and public service announcements.

Meetings with local public officials and private organizations can be extremely valuable for gaining local support and cooperation not only in conducting the inventory but also in "selling" the overall wellhead protection plan. Agencies and organizations who should be interviewed by the inventory staff include county health departments, soil local and regional planning agencies, emergency planning agencies, industrial and business organizations, labor union officials, farmers organizations and environmental groups. In addition to the education and public relations advantages of these meetings, they give the inventory staff a sense of direction as to what information is needed, what information is available, where it can be obtained and how reliable it is.[9]

4.4 Community-Right-to-Know Information

Attached to the 1986 Amendments to the Superfund Act (Comprehensive Environmental Response, Compensation, and Liability Act of 1980), known as SARA (Superfund Amendments and Re-authorization Act) was a provision commonly referred to as the Emergency Planning and Community-Right-to-Know Act (EPCRA), or SARA Title III.

EPCRA requires detailed information about the nature of hazardous substances in or near communities be made available to the general public. The law also provides stiff penalties for companies that do not comply, and allows citizens to file lawsuits against companies and government agencies to force them to obey the law.

EPCRA contains four major provisions:

1) Planning for chemical emergencies.
2) Emergency notification of chemical accidents and releases.
3) Reporting of hazardous chemical inventories.
4) Toxic chemical release reporting.

The law required the governor of each state to appoint a State Emergency Response Commission to handle the various phases of the law. The state agency in charge in Tennessee is the Tennessee Emergency Management Agency (TEMA). TEMA is the contact for both emergency response and hazardous chemical inventories and has a toll-free number (1-800-262-3300). Facilities are also required to report hazardous chemical inventories to the local fire department and Local Emergency Planning Committee.

Under 40CFR Part 300.21 (Section 311) and 300.25 (Section 312) of EPCRA, facilities are required to perform initial reporting on each hazardous chemical (Section 311) which includes material safety data sheets (MSDSs) and annual inventory reporting (Section 312) of hazardous chemicals at the facility.[18]

EPCRA also has a provision for toxic release chemical reporting. This portion of the law requires industrial facilities that manufacture or process more than 25,000 pounds (or otherwise use at least 10,000 pounds) of toxic chemicals to report the amounts that they either release to the environment or transfer to other locations. EPA makes this information available to the public through the Toxics Release Inventory (TRI), a nationwide computer database. The Pollution Prevention Act of 1990 expanded TRI reporting requirements to include the quantity of chemicals recycled, burned for energy recovery, treated or disposed of on- or off-site.

Contacting the local fire department or local emergency planning committee (commonly located in the county sheriff's office and functioning as the civil defense contact) regarding chemicals used at facilities within the wellhead protection area (Zones 1 and 2) should be an integral part of the overall contaminant source inventory process. Having a member of the local fire department involved with the contaminant source inventory would help in this regard. EPCRA reporting actually provides a significant shortcut to the process once the facilities within the wellhead protection area have been identified and tied to a map location. A current list of chemicals used at the facility and chemicals which have been used since EPCRA reporting requirements began in 1988 should be included in the contaminant source inventory submitted to the Division of Water Supply. Toxic release incidences (TRIS reporting) within the wellhead protection area should also be included.

4.5 State Agencies

The Tennessee Department of Environment and Conservation has various divisions that regulate various waste handling, disposal, product storage and mineral extraction activities. These agencies maintain a wide range of permits, reports, maps, records, and data sheets. Many local agencies such as county health departments, emergency planning agencies, fire departments and county agricultural offices have similar records.

The inventory team for category 2, 3, and 4 PWS should check with the Environmental Assistance Centers for the Divisions listed below within the Department of Environment and Conservation on any available historical information on past chemical handling and information on spills, leaks, accidents and other on-site occurrences for the facilities which may have resulted in a release to ground water. The phone numbers for the Environmental Assistance Centers were given in Section 1.0 (all the divisions have one central number). For a discussion of the State's role in the Wellhead Protection program, the reader is referred to Section 6.0.

- Division of Underground Storage Tanks
  - Underground petroleum storage tanks
- Division of Solid Waste Management
  - Landfills
  - Hazardous Waste Generators
  - Treatment, Storage & Disposal Facilities
- Division of Ground Water Protection
  - Closely spaced septic tanks or multi-user septic tanks (apartments, industries); identified problem

areas

Division of Superfund

Hazardous substance disposal sites

Division of Water Pollution Control

Surface water contamination and discharge permits

Division of Water Supply

Injection well permits and Ground water contamination

By the time Category 2, 3 and 4 PWS are ready to do their inventories, much of the Department's information should be available on a statewide database making it possible for the Department to readily supply this information to the PWS.

4.6 Applying the Potential Contaminant Source Inventory

The first stage in identifying potential contaminant sources is the preparation of a land use overlay map for the wellhead protection area addressed previously. This map will help the PWS establish the threat that the various types of land uses pose to the quality of the ground water supplying the PWS. A good starting point for this map is the community's zoning map or current land use map, which allocates sections of your community for specific land uses, including residential, commercial, and industrial uses. These zones create concentrations of businesses; if these concentrations are located in the recharge zone of the aquifer, they can increase the threat to your resource.

An important part of preparing the overlay map is identifying past and present waste disposal sites. These disposal sites might be easily recognizable as sewage treatment works, landfills, or underground injection wells, but care must be taken also to locate small commercial and industrial waste areas, such as lagoons and drywells. Areas with concentrated clusters of residential underground septic systems also should be included on the map.

Where possible, abandoned wells should be considered in the inventory and addressed in the management plan. Improperly constructed and/or abandoned wells may be a concern as they can have a considerable impact on the ground water. Improperly abandoned wells act as a conduit through which contaminants can reach the aquifer, particularly if the well casing has been removed or becomes corroded (or leaks along outside of casing where no seal between casing and formation). In addition, some people use abandoned wells to dispose of wastes such as used motor oil. Abandoned exploratory wells (e.g., oil and gas, coal) or test hole wells are frequently uncovered and improperly sealed (or not sealed at all) and can impact the water quality of drinking water aquifers.

Active drinking water supply wells that are poorly constructed can also result in ground water contamination. Construction problems such as faulty or cracked casings or lack of concrete pads allow outside water and any accompanying contaminants to flow into the well.

4.7 Inventory Reporting

Tennessee's Wellhead Protection Regulations require that PWS must complete an inventory of all potential pollution sources in and around their wellfields within their delineated wellhead protection areas. Pollution source inventory data, along with a location map and the required photographs, must be submitted to Tennessee's Department of Environment and Conservation, Division Water Supply for review and approval.

For all individual sources, minimum recorded data should include facility/owner name and address, facility type, description of potential pollution sources(s), map number and distance to nearest public water supply well or spring. The map of the wellfield area should include the locations of all public water supply wells, the boundaries for Zone 1 and Zone 2 and all potential sources identified by map number and/or symbols.

The inventory team should contact the county extension agent and/or local farmers to obtain descriptions of activities associated with farming that should include a list of agri-chemicals (fertilizers and pesticides) used on each crop-producing parcel of land over the past three years. From EPA's 1985 - 1992 National Pesticide Survey, the most common pesticides to occur in ground water were atrazine and metabolites (breakdown products) of dimethyl tetrachloroterephthalate (DCPA, commonly known as Dacthal), used in many utility easement weed control programs and for lawn care. Nitrates have also been identified in the ground water in other states. Other pesticides of particular concern include carbofuran, alachlor, and aldicarb.

For animal producing farms, recorded information should include descriptions of animal waste storage, treatment and disposal systems and practices. Individual land parcels where manure or wastewaters are applied should be identified. Fuel storage areas, chemical storage areas and machinery repair shops also should be inventoried.

The locations of major sanitary sewers, pipelines associated with utilities, oil and gas production and other fuel transportation systems should be recorded on the base map and described on the basis of product type, initial date of operation (installation), construction details and any documentation of substance releases. Highways, railroads, storm water systems and hazardous cargo routes also should be map-located and described.[9]

Each WHPA must further characterize the area around the well or spring for the contaminant source inventory by taking photographs north, northeast, east, southeast, south, southwest, west and northwest from the spring/well vantage point (facing outward from the spring or well). If the well or spring is enclosed in a building, the photographs must be taken at a point as near as possible to the well/spring that allows a view of the surrounding property. Included with the photographs will be a text on the description of the land uses (for example; agricultural, commercial, industrial, residential etc.). For Categories 3 and 4, aerial photographs of their wellhead protection area are also required. These should be available from the county Agricultural Stabilization and Conservation Service (ASCS) office or possibly TVA's Chattanooga office, depending on the PWS's location.

Appendix 4 contains a listing of names, addresses and phone numbers of the principal State agencies, other information. Other agency information sources also are noted.

Two copies of the Contaminant Source Inventory must be mailed to the Division of Water Supply according to the time schedule specified in Section 2.4.2.

4.8 <u>Inventory Updating</u>

Maintaining an accurate and comprehensive inventory of potential pollution sources in and around wellhead protection areas is on-going effort that requires periodic updating and oversight. Public records of facilities with hazardous materials as well as various waste disposal facilities should be reviewed annually to ensure that information is accurate and represents current conditions. Public water system officials and their inventory staff should maintain close coordination with State and local regulators charged with routine site inspections, permit reviews and emergency response activities.

A more comprehensive update and verification of pollution sources must be carried out at least every three years depending on factors such as rate of land development, changing land uses and increased water consumption. Two copies of the updated inventory along with any changes in the Wellhead Protection Plan must be submitted to the Division of Water Supply. All new potential pollution sources as well as changes in the operational status of the originally inventoried facilities should be identified. Most often, the inventory update can be accomplished by employing the same methods as in the original inventory (field inspections, meetings, records review, etc.), or by conducting phone surveys or mailing questionnaires.

Periodic pollution source inventory updating will help to ensure that all local land uses and associated pollution threats are accurately assessed and that current in-place management controls are providing adequate protection to the water supply source. Once inventory procedures have been carried out and proven to be effective, they should become part of a routine continuous process.

5.0 State Role in Wellhead Protection

Several federal laws help to protect ground water quality which are administered by the State with laws and regulations that essentially mirror the federal laws. The Federal Safe Drinking Water Act (SDWA) established the requirement for states to develop Wellhead Protection Programs and regulates the use of underground injection wells for disposal. It also provides EPA and the states with the authority to ensure that drinking water supplied by public water systems meets minimum health standards. Tennessee's Safe Drinking Water Act follows the Federal SDWA with the exception that Tennessee's underground injection program is regulated under the Tennessee Water Quality Control Act. It is under the authority of the Tennessee SDWA that the Wellhead Protection Regulations were written, which are administered by the Division of Water Supply.

The Federal Clean Water Act regulates surface water and ground water shown to have a connection with surface water. It sets standards for allowable pollutant discharges. Tennessee's Water Quality Control Act (WQCA) is the basic equivalent, but goes considerably beyond with respect to ground water. The WQCA specifically addresses and protects ground water as "waters of the State." The Division of Water Pollution Control handles surface water under WQCA. The Division of Water Supply's Ground Water Management Section is able to address ground water under WQCA and has the State's Underground Injection Control Program.

The Resource Conservation and Recovery Act (RCRA) regulates treatment, storage and disposal of hazardous and non-hazardous wastes (solid wastes) to prevent contaminants from leaching into ground water from municipal landfills, underground storage tanks, surface impoundments, and hazardous waste disposal facilities. The "cradle to grave" mandate of RCRA requires a trail of paperwork (a manifest document) to follow a hazardous waste from the point of generation, through transport and storage, to final disposal, to ensure proper handling of the wastes and provide accountability. The State's version of RCRA is the Hazardous Waste Management Act administered by the Division of Solid Waste Management.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) authorizes the government to clean up contamination or sources of potential contamination from hazardous waste sites or chemical spills, with a priority on those threatening drinking water supplies. Amendments to CERCLA include a "community-right-to-know" provision. The State's equivalent is the part II of the Hazardous Waste Management Act, handled by the Division of Superfund.

The Federal Insecticide, Fungicide and Rodenticide ACT (FIFRA) regulates pesticide use. Tennessee's designated agency for this is the Department of Agriculture. The Toxic Substances Control Act (TSCA) regulates manufactured chemicals. Tennessee has no equivalent for TSCA.

In 1991, under RCRA, EPA developed revised criteria for municipal solid waste landfills intended to protect ground water and surface water from contamination. The criteria include location restrictions (such as siting near wetlands or unstable areas such as karst); operating requirements (including a ban on hazardous wastes and liquid restrictions to control leachate sources); design standards; closure and post closure procedures; and ground water monitoring and corrective action.

In addition to determine the geographic boundaries for a landfill to which the new solid waste criteria apply, state agencies must review the hydrogeologic characteristics of the area, the volume and characteristics of the leachate, ground water quantity and direction of flow, ground water quality, the proximity and withdrawal rate of ground water users, and the availability of alternative drinking water supplies.

In 1991, the Bureau of Environment within the Department of Environment and Conservation established the Ground Water Advisory Committee to address and coordinate ground water issues among the divisions with ground water responsibilities. The Committee has expanded since then and now includes representatives from the following agencies:

- Department of Environment & Conservation
  - Division of Superfund
  - Division of Solid Waste Management
    - Hazardous Waste
    - Solid Waste
  - Division of Water Supply
    - Drinking Water
    - Ground Water Management Section (Chairman)
  - Division of Water Pollution Control
    - General (Division Director)
    - Nonpoint Source
  - Division of Radiological Health
  - Division of DOE Oversight
  - Division of Air Pollution Control
  - Division of Ground Water Protection
    - (Subsurface Sewage)
  - Division of Underground Storage Tanks
  - Division of Construction Grants and Loans
  - Div. of Pollution Prevention & Env. Awareness
  - Bureau of Environment
    - Land and DOE Oversight Programs Administrator
    - Water and Air Programs Administrator
- Department of Agriculture
  - Division of Plant Industries

The Ground Water Advisory Committee (GWAC) is chaired by the Manager of the Ground Water Management Section in the Division of Water Supply. The Ground Water Management Section is charged with writing Tennessee's Comprehensive State Ground Water Protection Plan with the support of the Ground Water Advisory Committee. The Ground Water Management Section within the Division of Water Supply will work through GWAC to keep the agencies advised of the Wellhead Protection Program and support where needed. The Department of Environment and Conservation's developing Geographic Information System (GIS) will play an important role in keeping the various divisions within the Department abreast of the location of PWS wells and springs and eventually wellhead protection areas as well.

There is also a provision within the Wellhead Protection Regulations for the PWS to notify the owner of the potential contamination source of activities that present a risk to the PWS well or spring, with a copy to the Division of Water Supply. This should be in the PWS's contingency plan.

These notification procedures should state that if a PWS becomes aware of any condition, situation, or action, particularly of any discharge or other release of any pollutant substance with any wellhead protection zone or wellhead management zone, which presents or may present a significant risk of contamination of the public water supply source, the PWS supplier will ta ke actions detailed below. The PWS is in a much better position to be aware of activities within its wellhead protection area and inform the Department of significant problems.

1) The manager or highest ranking official of the PWS should notify the owner or operator or the facility which is the source of the release of discharge by registered letter that the facility is located in a designated wellhead protection area and that such action presents a threat to the public water supply source. The notification should be addressed to one of the following persons, as most appropriate:

    a) the owner or principal operating officer of the business operating on the property where the discharge or release occurs; or

    b) the legal owner of the property on which the discharge or release occurs, as determined from tax records or other city, county or municipal records.

    c) This correspondence should also contain a request to the owner or operator of the property or facility to take appropriate measures to cease or abate the discharge or release in order to remove further threat to the public water supply source. Specific measures may be requested at the PWS's option, but are not a necessary part of the notification letter. The intent is to serve notice upon the property owner or facility owner or operator that his actions present a potential threat to the public water supply.

2) The manager or highest ranking official of the PWS should then notify the Division of Water Supply, Ground Water Management Section by copy of the notification letter sent certified mail. This notification should also include a map of the wellhead protection or management area with the location of the discharge or release noted, together with any additional clarifying information regarding the release, such as dates of occurrence, nature of material released, how released etc. Such notification of the Division will allow a follow-up investigation by the Department to be arranged in order to determine if a violation of a regulation has occurred, insure that the release is abated and possibly pursue enforcement action.

6.0 Management Plan for WHP Areas

The reader is referred to Appendix 8 for an overview of the wellhead protection "tools" available. The Land Management tools given in this table are taken from EPA's Wellhead Protection: A Guide for Small Communities.[9] This guide is an excellent help for all PWS, regardless of size.

It is recognized that PWS have limited tools at their disposal in protecting their water supply. That is why the solicitation of local government and the local planning/zoning commission support is required in the Wellhead Protection Regulations. It is further recognized that the PWS may not succeed in this endeavor -- a good faith effort is all that is required. Local government can support in the form of local ordinances and local zoning considerations (similar to that already done for floodplains). The PWS is also to request review and comment privileges for issues within the wellhead protection areas. This will help to keep the wellhead protection issue under consideration in activities within the wellhead protection area. The official designation of a wellhead protection area alone brings considerable focus and a major impact on protecting the area at the federal, state and local government level that may not initially be apparent to the PWS.

6.1 Planning for the Future

It is not anticipated that there will be many outright prohibition of already ongoing activities within wellhead protection areas; however, a key aspect of wellhead protection and prevention of contamination is planning for the future. A critical aspect of the wellhead protection plan is the identification of future hazards that threaten the wellhead protection areas. One method of identifying potential future problems is to analyze the community's "Development Plan" or "Master Plan". This plan generally gives some idea of the direction that land development in the community will take. The plan is usually based on local zoning maps to identify land areas that have been zoned for commercial and industrial use and that might prove to be trouble spots. The plan should be carefully evaluated by the PWS; it might prove inconsistent with the overall goals of wellhead protection. Often a development plan is only advisory in nature and therefore may be relatively easy to amend.

In addition to local master development plans, regional long-term development plans and statewide infrastructure plans should be reviewed to determine their possible impacts on the community's wellfields. These plans might indicate highway and major earthworks proposals, new prison or hospital facilities, and dams or dredging activities. Major expansion or maintenance plans of local water and power utilities should also be reviewed. The objective here is for your team to be aware of forthcoming changes to your ground water recharge zone so that you can pursue adequate protection measures.

Another method of determining future risks to the ground water is to conduct a "build-out analysis" of the community's zoning map. This is a done by using the land-use overlay map and existing zoning and subdivision regulations to determine the development potential of each land-use zone within the wellhead protection area. This allows the PWS to assess the implications to the aquifer if every section of developable land within the recharge zone was built upon. This "situation analysis" allows the PWS to investigate whether the community's zoning and development plans are compatible with its current and/or long-term need for ground water protection.

One important aspect of build-out analysis is that it can be used to help the PWS anticipate the community's future water supply needs. It can show the need for new wells (which should be located to minimize potential contamination). New wells offer the PWS the opportunity to implement wellhead protection practices that may have been difficult to carry out in established wellhead areas. Wellhead Protection considerations are required as part of new well siting criteria (see Section 8.0). The community should consider purchasing land for the purpose of managing the wellhead protection area for a future well. Alternatively, the local government can establish an ordinance to protect the area around the site for a future well. These actions will help ensure that the area does not have a contamination history when the new well is needed.[9]

6.2 Managing with Zoning, Ordinances, & Agreements

Communities traditionally have used zoning ordinances to control and direct the development within the community. Zoning has become a popular process for communities to safeguard floodplains and wetlands. A community can consider creating a zoning district to protect the aquifers, recharge areas, and areas of influence by modifying existing zoning ordinances or creating new ones. A ground water zoning ordinance could prohibit certain land uses while requiring special permitting or performance criteria for less hazardous activities. Zoning options can provide a variety of opportunities to prevent high-risk development or activities within your wellhead protection area. These options depend on the intensity of development in the area surrounding the wells. It is easiest to zone an area that is undeveloped and "unzoned." Such an area can be zoned for low density residential use.

Down-zoning consists of changing a zone that has already been designated for a specific land use to a zone that is more compatible with protection goals. This approach generally involves reducing allowable development densities. If an area has been zoned and is partially developed, it may be possible to "phase-in" zoning requirements over a period of time.

Large lot zoning of single family residences is another method of reducing source contamination through reduction in the number of septic systems. Conditional zoning allows certain low-risk land uses, while high-risk uses are allowed only under strict conditions. This approach can be used where zones have not been clearly defined.

Overlay zoning can be used to define environmentally sensitive areas over a pre-existing zoning map. The boundaries of your delineated wellhead protection area are unlikely to agree with established land-use boundary zones. An overlay map can help your community implement management regulations only in those portions of existing land use zones that fall within your wellhead protection area.

Zoning changes are often sensitive community issues and must not appear overly restrictive or discriminatory, or court action could result.

The most effective control over susceptible recharge areas occurs when the land is owned or controlled by the community. In this case, the community can establish a park, recreational facilities, or other community based land uses. Golf courses should be considered carefully, however, since the pesticides, fertilizers and heavy metals have been contributors to ground water contamination in states such as Florida. For large areas, acquiring the property is extremely expensive and impractical. Some non-profit organizations, such as regional land trusts, work to acquire environmentally sensitive land areas.

Some alternatives to ownership of land still allow some control over vulnerable recharge zones. These include acquisition of "conservation easements" and "restrictive covenants." Conservation easements are voluntary arrangements restricting a landowner from performing certain activities (such as using hazardous materials or installing septic systems) on the land covered by the easement. Easements may also be purchased from the landowner. The landowners may continue to conduct non-threatening land use activities in this area. The property may change hands, but the land restrictions are attached to the deed. Restrictive covenants are similar to easements in that they are attached to the deed and apply to subsequent landowners. Easements are held by another party who can enforce restrictions, however, whereas restrictive covenants can only be enforced by other property owners similarly restricted. Restrictive covenants may also prohibit dangerous land practices and restrict development densities.

6.3 Encouraging Best Management Practices

In general, ground water contamination stems from the misuse and improper disposal of liquid and solid wastes; the illegal dumping or abandonment of household, commercial, or industrial chemicals; the accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; or the improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities. Generally, when the potential sources are used and managed properly, ground water contamination is not likely to occur.[9]

Best management practices (BMPs) are standard operating procedures for a particular industry, agriculture or commercial activity that can limit the threat to the environment posed by ongoing practices, such as pesticide application or storage and use of hazardous substances (EPA, 1989b). BMPs prevent the release of toxic substances into the environment or control these releases in an environmentally sound manner. BMPs also encourage operating and design standards to ensure the safety of plant operators and the public.

Facilities in the wellhead protection area that store or handle hazardous substances - heavy industrial plants, dry cleaners, gas stations, auto repair workshops, and transportation facilities such as trucking, railroad, bus depots and airports - should consider implementing BMPs. Examples of BMPs include restricting and carefully monitoring hazardous materials storage and disposal, and limiting or introducing collection systems for roadway deicing chemicals. For agriculture, BMPs include minimal chemical application, chemical application only during dry periods when infiltration is slow, and erosion and sedimentation controls (EPA, 1989b).

In working with farmers, encouraging BMPs is particularly useful. If the farmer will follow label instructions on Restricted Use Pesticides which have "Ground Water and Surface Water Concerns" on the manufacturer's label (such as atrazine) there are recommended procedures which will help to reduce the risk to ground water.

The label for atrazine (AAtrex 4L by CIBA-GEIGY) specifically mentions "Ground Water and Surface Water Concerns" and under the heading "Environmental Hazards" states:

> "Atrazine can travel (seep or leach) through soil and can enter ground water which may be used as drinking water. Atrazine has been found in ground water. Users are advised not to apply atrazine to sand and loamy sand soils where the water table (ground water) is close to the surface and where these soils are permeable, i.e., well-drained. Your local agricultural agencies can provide further information on the type of soil in your area and the location of ground water.
>
> This product may not be mixed/loaded, or used within 50 ft. of all wells, including abandoned wells, drainage wells, and sinkholes."

The farmers should already be applying these pesticides according to manufacturer's directions to avoid possible penalties from the Department of Agriculture and certainly as a BMP. The PWS may be able to get an agreement with the farmer to increase this distance for wells, springs and sinkholes to at least 100, and preferably 200 feet. Dumping out excess pesticide or used containers of the pesticide in the area should also be covered.

The farmer would also be well advised to make use of a backflow prevention device to prevent pesticide contaminated waters from siphoning back into his farm well when filling up pesticide tanks, etc. and contaminating not only his well, but the aquifer as well. If he is using water from a PWS without a backflow prevention device, he is violating regulations for Public Water Systems and could be subject to enforcement by the Division of Water Supply.

Other pesticide applications can also be a concern in wellhead protection areas such as from pest control applicators, right-of-way applicators, commercial applicators, etc. The Division of Water Supply will be working with the Department of Agriculture in educating licensed applicators about wellhead protection.

6.4 Contingency Planning

A vital aspect of a wellhead protection program is the development of a contingency plan. This ensures that the community has an alternative water supply in the event of contamination of the primary source. The PWS should develop both short-term or permanent water supply alternatives.

The PWS's contingency plan should contain emergency response procedures to be implemented upon release of contaminants into the environment. These procedures should identify the appropriate personnel to contact at the state and federal level, the appropriate equipment to have on hand, and a structured plan of action to respond as quickly and effectively as possible, to mitigate any environmental damage resulting from such a release. The contingency plan will benefit from good coordination mechanisms, such as an emergency response team, when reacting to emergency spill situations. The PWS is not expected to establish an emergency response team, only to have a list of contacts such as the Tennessee Emergency Management Agency and Local Emergency Response Committee readily available.

The contingency plan should include the notification of the Tennessee Department of Environment and Conservation and the owner of the potential contaminant source if a PWS becomes aware of any condition, situation, or action, particularly of any discharge or other release of any polluting substance within the wellhead protection zone or wellhead management zone, which presents or may present a significant risk of contamination of the public water supply source. This notification is covered in further detail in Section 6.0.

The other requirements of the contingency plan are covered in the Wellhead Protection Regulations [1200-5-1-.34(3)(a)] and will not be addressed here.

6.5 Submitting the Wellhead Protection Plan

Each PWS Wellhead Protection Plan must be submitted according to the time schedule previously discussed. Two copies must be sent for approval to the Division of Water Supply, one to the address given at the beginning of this document, the other to the appropriate Water Supply Environmental Assistance Center (see Appendix 1). Once the PWS has been notified in writing that the Plan has been approved, a copy of the Plan must be sent to the county government and the county/regional planning commission.

The Wellhead Protection Plan will be reviewed for compliance by Division of Water Supply Environmental Assistance Center personnel as a part of the PWS's sanitary survey.

Once the plan has been submitted and approved, the potential contaminant source inventory must be updated at least every three years and submitted to the Division of Water Supply along with any changes which have occurred in the Wellhead Protection Plan.

7.0 Public Education

A public education and notification plan must be apart of the wellhead protection plan. The notification plan should provide the name of the newspaper and copy of the proposed text to be submitted as a minimum requirement. The submitted plan can also provide for other educational opportunities, such as outreach programs to public schools (which might include slides, locally produced videos or PWS tours), local libraries, environmental and civic clubs and scouts, radio public service announcements, brochures and exhibits at annual affairs.

The major aim of public education is to increase awareness of the threats of ground water contamination, encourage voluntary protection (such as conservation measures and environmentally sound waste management), and create support for protective regulatory initiatives (such as industrial controls and zoning changes). Early awareness during the wellhead protection area delineation and plan development will be of considerable value in the overall effect of the program.

Outreach to the community may include:

An explanation of what ground water is and the effects of ground water contamination on public health.

Information on how each business and each individual contributes to water pollution.

Information on how to take good care of a septic system.

Information on the proper disposal of pesticides, used oil, solvents, and other contaminants.

Water conservation techniques for all activities, whether commercial, industrial, residential, or agricultural.

A description of your community's wellhead protection program, listing your team's accomplishments to date and goals for the future.

Tennessee Wellhead Protection Regulations require that at a minimum newspaper articles be placed twice yearly in a local weekly paper. A PWS shall submit in a daily newspaper of general circulation in the area served by the system, two (2) times per calendar year. If the area served by the PWS is not served by a daily newspaper of general circulation, notice shall be given by circulation in a weekly newspaper of general circulation serving the area. Other methods of public education may also be used. The information provided to the local newspaper must include, at a minimum:

1) the types of activities which may result in contamination of the ground water in the wellhead protection area;

2) the methods to protect the designated area;

3) a request for the public to report activities that may result in ground water contamination;

4) the importance of ground water protection; and

5) a map of the designated wellhead protection area.

The community should provide alternatives to disposing of potentially contaminating substances (such as providing a central location point where waste oil and other materials can be collected and recycled). The Division of Solid Waste Assistance has contracted with a private firm for the collection of household hazardous waste statewide, with each county coordinating a collection point and time (for Memphis, Nashville, and Knoxville there will be permanent collection facilities built). Another method of reaching a large portion of the community is the use of road signs indicating the most vulnerable areas in your wellhead protection zone.

8.0 Requirements for New Ground Water Sources

8.1 New Sources

Prior to the construction of a new groundwater source after the effective date of the wellhead Protection Rules (scheduled on January 5, 1994), each PWS shall develop a Preliminary Evaluation Report (PER). The PWS must submit the PER with the Engineering Plans and Specification to the Department for approval. After the new source is constructed, a Wellhead Protection Plan must be developed pursuant to these rules. The PWS has eighteen months to implement a Wellhead Protection Plan upon completion of construction of the new source.

A PWS must consider potential contamination sources in determining the location of the new ground water source. The PER must include a list of potential contamination sources within the potential Zone 1 area. Additionally, the PWS will work with appropriate local governing bodies to limit the future location of any potential contamination source or activity within Zone 1.

New PWS wells must receive site approval from the Division before drilling. New well approval is conditioned upon the Public Water System complying with all sections of the Wellhead Protection Regulation. Approval of new wells by the Division of Water Supply will depend on the ability of the PWS to provide the highest degree of reliable control of the area. The Division of Water Supply may deny its approval for new wells to be put into service if these requirements cannot be met.

8.2 Backup Sources

Wells or springs that are a regular backup to a PWS must also have a Wellhead Protection Plan. Those not currently used as backup will be considered as new sources and require approval as outlined under New Sources.

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4. U.S. Environmental Protection Agency. 1991. Delineation of Wellhead Protection Areas in Fractured Rocks. EPA 570/9-91-009.

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9. U.S. Environmental Protection Agency. 1993. Wellhead Protection: A Guide for Small Communities. EPA 625/R-93-002.

10. South Carolina Department of Health and Environmental Control. 1992. Wellhead Protection Guidance Document for South Carolina: Local Ground-Water Protection.

11. Georgia Department of Natural Resources. 1992. Georgia Wellhead Protection Manual for Public Water Supplies.

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18. EPA. 1988. Chemicals in Your Community; A Guide to the Emergency Planning and Community-Right-to-Know Act.

19. EPA. 1990. Citizen's Guide to Ground Water Protection. Office of Water, 440/6-90/004.

APPENDICES

APPENDIX 1
ACTIVE PUBLIC WATER SYSTEMS
GROUND WATER SOURCES
IN ORDER BY NAME
11/02/93

PWSID	System Name	County	Category	No. Service Connections	Average Production	Geology	Recharge Value(ft/yr)	EAC
0000002	ADAMSVILLE WATER SYSTEM	MCNAIRY	3	2,100	693,000	C-sand	N/A	02
0000005	ALAMO WATER DEPARTMENT	CROCKETT	3	1,180	292,000	T-sand	N/A	02
0000539	ANTIOCH WATER COMPANY	HENRY	2	75	23,000	C-sand	N/A	02
0000018	ARDMORE WATER SYSTEM	GILES	2	462	304,000	M-carb	.41	04
0000019	ARLINGTON WATER SYSTEM	SHELBY	3	446	409,000	T-sand (con)	N/A	02
0000035	ATWOOD WATER SYSTEM	CARROLL	2	450	87,000	T-sand	N/A	02
0000329	BANEBERRY U. D.	JEFFERSON	2	115	15,000	C/O carb	.43	03
0000658	BARE TRAILER PARK	RHEA	1	13	u	N/A	N/A	01
0000765	BARTLETT WATER SYSTEM	SHELBY	4	11,472	1,460,000	T-sand	N/A	02
0000805	BAYS MOUNTAIN M.H.P.	BLOUNT	1	35	u	N/A	N/A	03
0000045	BELLS PUBLIC UTILITY DISTRICT	CROCKETT	2	632	171,000	T-sand	N/A	02
0000046	BELVIDERE RURAL U.D.	FRANKLIN	2	399	186,000	M-carb	.39	01
0000048	BENTON WATER SYSTEM	POLK	2	754	216,000	C/O-carb	.43	01
0000050	BETHEL SPRINGS WATER SYSTEM	MCNAIRY	2	387	77,000	C-sand	N/A	02
0000051	BIG SANDY WATER DEPT	BENTON	2	320	78,000	C-sand	N/A	02
0000061	BLUFF CITY WATER SYSTEM	SULLIVAN	2	837	226,000	C/O-carb	.43	05
0000063	BOLIVAR WATER PLANT%B. TIGNER	HARDEMAN	4	2,741	1,226,000	C-sand	N/A	02
0000067	BRADFORD WATER SYSTEM	GIBSON	2	485	168,000	T-sand	N/A	02
0000070	BRIGHTON WATER SYSTEM	TIPTON	2	456	113,000	T-sand (con)	N/A	02
0000080	BROWNSVILLE WATER DEPT.	HAYWOOD	4	4,735	1,852,000	T-sand	N/A	02
0000081	BRUCETON WATER SYSTEM	CARROLL	3	700	575,000	C-sand	N/A	02
0000843	BUSH BROTHERS #2	JEFFERSON	1	13	u	N/A	N/A	03
0000932	CAMELOT CARE CENTER	ROANE	1	1	500	N/A	N/A	03
0000098	CEDAR GROVE UTILITY DISTRICT	CARROLL	2	450	210,000	T-sand	N/A	02
0000101	CENTER GROVE-WINCHESTER SPGS	FRANKLIN	3	1,599	341,000	M-carb	.39	01
0000849	CHALET VILLAGE NORTH	SEVIER	2	334	55,000	C-rock	.67	03
0000104	CHAPEL HILL WATER SYSTEM	MARSHALL	2	402	107,000	O-carb	.39	04
0000138	CHEROKEE HILLS U.D.	POLK	2	112	55,000	C-rock	.67	01
0000062	CHINQUAPIN GROVE U.D.	SULLIVAN	2	665	99,000	C/O-carb	.43	05
0000885	CHUMNEY'S TRAILER PARK	HENDERSON	1	46	u	N/A	N/A	02

0000115	CLARKSBURG UTILITY DISTRICT	CARROLL	2	450	120,000	C-sand	N/A	02
0000826	CLEAR FORK UTILITY DISTRICT	CLAIBORNE	2	496	83,000	P-sand	.43	03
0000901	CLOAR'S TRAILER PARK	OBION	1	1	u	N/A	N/A	02
0000245	COLD CREEK CORRECTIONAL FAC.	LAUDERDALE	3	700	356,000	T-sand (con)	N/A	02
0000485	COLD SPRINGS UTILITY DISTRICT	JOHNSON	2	157	73,100	C-rock	.67	05
0000126	COLLIERVILLE WATER DEPT	SHELBY	4	5,500	2,650,000	T-sand	N/A	02
0000127	COLLINWOOD WATER DEPT	WAYNE	2	676	166,000	M-carb	.41	04
0000136	COPPERHILL WATER DEPARTMENT	POLK	2	270	228,000	C-rock	.67	01
0000933	COUNTRY JUNCTION	HENRY	1	20	u	N/A	N/A	02
0000945	COUNTRYSIDE RESORT CMPGD	WILSON	1	98	u	N/A	N/A	04
0000006	COUNTY WIDE U. D.	CROCKETT	4	3,027	1,049,000	T-sand	N/A	02
0000144	COVINGTON WATER DEPT	TIPTON	4	3,051	1,353,000	T-sand (con)	N/A	02
0000146	COWAN BOARD OF PUBLIC UTILITY	FRANKLIN	2	729	144,000	M-carb	.41	01
0000148	CROCKETT MILLS U.D.	CROCKETT	2	291	91,000	T-sand	N/A	02
0000848	CUMBERLAND MTN RETREAT	CUMBERLAND	1	31	u	N/A	N/A	02
0000170	DANDRIDGE WATER DEPARTMENT	JEFFERSON	2	986	261,000	C/O-carb	.43	03
0000183	DECATUR WATER DEPARTMENT	MEIGS	3	722	375,000	C/O-carb	.43	01
0000186	DECATURVILLE WATER SYSTEM	DECATUR	2	750	160,000	C-sand	N/A	02
0000187	DECHERD WATER DEPARTMENT	FRANKLIN	3	1,248	331,000	M-carb	.39	01
0000912	DEERFIELD RESORT WATER SYSTEM	CAMPBELL	1	39	u	N/A	N/A	03
0000397	DIXIE LEE UTILITY DISTRICT	LOUDON	3	2,520	596,000	C/O-carb	.43	03
0000403	DOWELLTWN-LIBERTY U.D.	DE KALB	2	350	70,000	O-carb	.41	04
0000196	DRESDEN WATER DEPARTMENT	WEAKLEY	3	1,253	491,000	T-sand	N/A	02
0000209	DYER WATER DEPARTMENT	GIBSON	3	1,110	278,000	T-sand	N/A	02
0000212	DYERSBURG SUB CONS U.D.	DYER	3	1,430	385,000	T-sand(con)	N/A	02
0000211	DYERSBURG WATER DEPT.	DYER	4	6,775	3,880,000	T-sand(con)	N/A	02
0000618	EAST SEVIER COUNTY U.D.	SEVIER	2	64	43,000	C/O-carb	.43	03
0000219	EASTSIDE UTILITY DISTRICT	HAMILTON	4	10,650	3,650,000	C/O-carb	.43	01
0000220	ELBRIDGE WATER ASSOCIATION	OBION	3	1,064	211,000	T-sand(con)	N/A	02
0000221	ELIZABETHTON WATER DEPT.	CARTER	4	9,800	5,057,000	C/O-carb	.43	05
0000231	ERWIN UTILITIES	UNICOI	4	3,933	1,952,000	C-rock		05
0000232	ESTILL SPRINGS WATER DEPT.	FRANKLIN	3	1,175	359,000	M-carb	.41	01
0000094	FIRST U.D. OF CARTER CO.	CARTER	4	1,860	1,032,000	C/O-carb	.43	05
0000855	FIRST U.D. OF HAWKINS CO,#2	HAWKINS	3	2,300	671,000	C/O-carb	.43	05
0000703	FIRST U.D. OF TIPTON CO.	TIPTON	3	2,220	602,000	T-	N/A	02

						sand(con)		
0000854	FOXFIRE HOMEOWNERS ASSOC.	SULLIVAN	1	40	10,000	N/A	N/A	05
0000832	FREDA BELL M.H.C.	LOUDON	1	16	u	N/A		03
0000248	FRIENDSHIP WATER COMPANY	CROCKETT	2	241	71,000	T-sand	N/A	02
0000254	GALLAWAY WATER DEPARTMENT	FAYETTE	2	280	214,000	T-sand	N/A	02
0000255	GATES WATER DEPARTMENT	LAUDERDALE	2	303	56,000	T-sand(con)		
0000262	GERMANTOWN WATER DEPT.	SHELBY	4	10,400	4,260,000	T-sand(con)	N/A	02
0000709	GIBSON CO MUN WATER DIST #1	GIBSON	2	863	130,000	T-sand	N/A	02
0000788	GIBSON CO MUN WATER DIST #2	GIBSON	2	477	94,000	T-sand	N/A	02
0000812	GIBSON CO MUN WATER DIST #3	GIBSON	2	429	163,000	T-sand	N/A	02
0000813	GIBSON CO MUN WATER DIST #4	GIBSON	2	524	156,000	T-sand	N/A	02
0000815	GIBSON CO MUN WATER DIST #5	GIBSON	2	219	44,000	T-sand	N/A	02
0000816	GIBSON CO MUN WATER DIST #6	GIBSON	2	135	30,000	T-sand	N/A	02
0000263	GIBSON WATER DEPARTMENT	GIBSON	2	162	25,000	T-sand	N/A	02
0000913	GILMORE WATER SYSTEM	GRAINGER	1	48	u	N/A	N/A	03
0000264	GLADEVILLE U.D. #1	WILSON	4	3,167	723,000	O-carb		04
0000265	GLEASON WATER DEPARTMENT	WEAKLEY	3	640	346,000	T-sand	N/A	02
0000267	GRAND JUNCTION WATER DEPT.	HARDEMAN	2	320	212,000	T-sand	N/A	02
0000451	GRAND VALLEY LAKES OWNERS	HARDEMAN	2	120	18,000	T-sand	N/A	02
0000269	GRAYSVILLE WATER DEPT.	RHEA	2	537	169,000	P-sand	.43	01
0000270	GREAT SMOKY MTNS NATL PARK	SEVIER	1	18	15,370	N/A	N/A	03
0000276	GREENFIELD WATER DEPT.	WEAKLEY	3	980	327,000	T-sand	N/A	02
0000906	GRINDSTONE ESTATES M.H.P.	HAMILTON	2	270	46,000	C/O-carb	.43	01
0000279	HALLS WATER SYSTEM	LAUDERDALE	3	1,950	672,000	T-sand(con)	N/A	02
0000282	HAMPTON UTILITY DISTRICT	CARTER	3	1,003	603,000	C-rock	.67	05
0000923	HARBERT HILLS ACADEMY N.H.	HARDIN	1	1	u	N/A	N/A	02
0000943	HARPER BLUFF SUBDIVISION	GRAINGER	1	42	u	N/A	N/A	03
0000285	HARPETH UTILITY DISTRICT	DICKSON	2	840	151,000	M-carb	.41	04
0000293	HENDERSON WATER DEPARTMENT	CHESTER	3	2,165	914,000	C-sand	N/A	02
0000295	HENNING WATER DEPARTMENT	LAUDERDALE	2	384	131,000	T-sand(con)		
0000296	HENRY WATER SYSTEM	HENRY	2	200	76,000	T-sand		02
0000899	HICKORY STAR MARINA	UNION	1	47		N/A		03
0000874	HICKORY VALLEY WATER SYSTEM	HARDEMAN	2	105	33,000	T-sand	N/A	02
0000176	HILL LAKE WATER SYSTEM	RHEA	1	23	u	N/A	N/A	01
0000025	HILLSIDE TRAILER PARK	MCMINN	1	27	u	N/A		01
0000426	HIWASSEE COLLEGE	MONROE	2	48	42,000	C/O-carb		01

0000304	HOHENWALD WATER SYSTEM	LEWIS	3	2,234	982,000	M-carb	.41	04
0000310	HOLLOW ROCK WATER DEPT.	CARROLL	1	350	u	N/A	N/A	02
0000311	HORNBEAK U. D.	OBION	2	476	92,000	T-sand(con)		02
0000314	HUMBOLT UTILITIES-WATER DEPT.	GIBSON	4	4,255	2,150,000	T-sand(con)	N/A	02
0000316	HUNTINGDON WATER DEPARTMENT	CARROLL	3	2,045	662,000	C-sand	N/A	02
0000317	HUNTLAND WATER SYSTEM	FRANKLIN	2	433	126,000	M-carb	.41	01
0000920	INDIAN CREEK TRAILER PARK	CLAIBORNE	1	18	u	N/A	N/A	03
0000299	JACKSON WATER SYSTEM	MADISON	4	24,223	10,850,000	T-sand(con)	N/A	02
0000028	JOHNSON TRAILER PARK	MCMINN	1	15	u	N/A	N/A	01
0000347	KENTON WATER DEPARTMENT	OBION	2	610	136,000	T-sand	N/A	02
0000055	KENTUCKY LAKE HEIGHTS WTR SYS	BENTON	2	148	25,000	C-sand	N/A	02
0000918	KINGSWOOD SCHOOL	GRAINGER	1	1	u	N/A	N/A	03
0000382	LA GRANGE WATER DEPARTMENT	FAYETTE	2	83	44,000	T-sand	N/A	02
0000384	LAKEMONT U.D.	HAWKINS	1	44	u	N/A	N/A	05
0000846	LAKESHORE HEIGHTS SUBDIVISION	GRAINGER	1	43	u	N/A	N/A	03
0000581	LAUDERDALE CO. WATER SYSTEM	LAUDERDALE	4	3,277	673,000	T-sand (con)	N/A	02
0000936	LAUREL MTN LAKES WATER ASSOC	MONROE	1	17	u	N/A	N/A	01
0000178	LAURELBROOK SANITARIUM-SCHL	RHEA	2	38	32,000	P-sand	.43	01
0000916	LEATHERWOOD WATER DIST, INC.	STEWART	1	103	u	N/A	N/A	04
0000399	LEOMA UTILITY DISTRICT	LAWRENCE	2	480	105,000	M-carb	.41	04
0000361	LEWANDS WATER SYSTEM	ROANE	1	24	2,700	N/A	N/A	03
0000764	LINCOLN CO. BD. P.U. #1	LINCOLN	4	4,112	1,170,000	M-carb	.41	04
0000290	LINCOLN MEMORIAL UNIVERSITY	CLAIBORNE	2	20	113,000	C/O-carb	.43	03
0000762	LITTLE CREEK SANITARIUM	KNOX	2	50	41,000	C/O-carb	.43	03
0000083	LOON BAY PROPERTY OWNERS ASC.	STEWART	1	52	3,000	N/A	N/A	04
0000408	LORETTO WATER DEPARTMENT	LAWRENCE	2	897	200,000	M-carb	.41	04
0000415	LUTTRELL-BLAINE-CORRYTON U.D.	UNION	3	1,351	269,000	C/O-carb	.43	03
0000029	MALLARD RIDGE MOBILE ESTATES	TIPTON	1	57	17,000	N/A	N/A	02
0000435	MARTIN WATER DEPARTMENT	WEAKLEY	4	3,705	1,360,000	T-sand	N/A	02
0000935	MASON HALL DEVELOPMENT CORP.	OBION	1	80	u	N/A	N/A	02
0000440	MASON WATER DEPARTMENT	TIPTON	2	582	220,000	T-sand (con)	N/A	02
0000441	MAURY CITY WATER DEPARTMENT	CROCKETT	2	417	92,000	T-sand	N/A	02
0000442	MAYNARDVILLE WATER DEPT.	UNION	3	1,052	352,000	C/O-carb	.43	03
0000420	MCEWEN WATER DEPARTMENT	HUMPHREYS	2	785	267,000	M-carb	.41	04
0000421	MCKENZIE WATER DEPARTMENT	CARROLL	3	2,195	895,000	T-sand	N/A	02

0000422	MCLEMORESVILLE WATER DEPT.	CARROLL	2	132	35,000	T-sand	N/A	02
0000445	MEDINA WATER DEPARTMENT	GIBSON	2	379	68,000	T-sand	N/A	02
0000450	MEMPHIS LIGHT GAS WATER DIV.	SHELBY	4	250,437	147,400,000	T-sand(con)	N/A	02
0000453	MERCER UTILITY DISTRICT	MADISON	1	70	15,000	T-sand	N/A	02
0000454	MICHIE WATER DEPARTMENT	MCNAIRY	2	789	220,000	C-sand	N/A	02
0000455	MIDDLETON WATER DEPARTMENT	HARDEMAN	2	339	154,000	C-sand	N/A	02
0000888	MIDWAY TRAILER COURT	DYER	1	14	u	N/A	N/A	02
0000798	MILAN ARSENAL #1	GIBSON	3	30	342,000	T-sand	N/A	02
0000458	MILAN WATER DEPARTMENT	GIBSON	4	3,968	1,200,000	T-sand	N/A	02
0000463	MILLINGTON WATER DEPARTMENT	SHELBY	4	2,700	1,040,000	T-sand(con)	N/A	02
0000472	MOORESBURG UTILITY DISTRICT	HAWKINS	2	235	62,000	C/O-carb	.39	05
0000477	MOSCOW WATER DEPARTMENT	FAYETTE	2	205	64,000	T-sand	N/A	02
0000488	MOUNT PLEASANT WATER SYS. #1	MAURY	3	2,186	874,000	M-carb	.41	04
0000385	MOUNTAIN VIEW WATER SYSTEM	JEFFERSON	1	50	u	N/A	N/A	03
0000490	MUNFORD WATER DEPARTMENT	TIPTON	3	1,601	534,000	T-sand(con)	N/A	02
0000937	NATCHEZ TRACE WILDERNESS PRG.	MAURY	1	1	u	N/A	N/A	04
0000468	NAVAL AIR STATION-MEMPHIS	SHELBY	4	937	1,710,000	T-sand(con)	N/A	02
0000496	NEWBERN WATER DEPARTMENT	DYER	3	2,637	940,000	T-sand(con)	N/A	02
0000657	NEWPORT RESORT WATER SYSTEM	RHEA	1	40	7,000	N/A	N/A	01
0000511	NOLENSVILLE-COLLEGE GROVE U.D.	WILLIAMSON	3	2,300	510,000	O-carb	.41	04
0000513	NORRIS WATER COMMISSION	ANDERSON	3	725	339,000	C/O-carb	.43	03
0000540	NORTH EAST HENRY CO. U.D.	HENRY	3	1,063	230,000	C-sand	N/A	02
0000195	NORTH STEWART UTILITY DISTRICT	STEWART	3	1,150	229,000	M-carb	.41	04
0000518	NORTHWEST DYERSBURG U.D.	DYER	3	1,111	252,000	T-sand(con)	N/A	02
0000841	NORTON CREEK WATER SYSTEM	SEVIER	1	35	u	N/A	N/A	03
0000180	OAK SHADOWS M.H.P.	RHEA	1	32	u	N/A	N/A	01
0000521	OAKLAND WATER DEPARTMENT	FAYETTE	2	705	167,000	T-sand	N/A	02
0000524	OBION WATER DEPARTMENT	OBION	2	700	227,000	T-sand(con)	N/A	02
0000525	OCOEE UTILITY DISTRICT	POLK	3	2,515	684,000	C/O-carb	.43	01
0000208	OLD UNION WATER SYSTEM	SEQUATCHIE	1	12	u	N/A	N/A	01
0000523	OLIVER SPRINGS WATER BOARD	ROANE	3	1,997	441,000	C/O-carb	.43	03
0000535	ORME WATER SYSTEM	MARION	2	36	47,000	P-sand	.43	01
0000536	PARIS BOARD OF PUBLIC UTILITIES	HENRY	4	4,750	2,030,000	T-sand	N/A	02

0000551	PIKEVILLE WATER SYSTEM	BLEDSOE	3	1,034	344,000	O-carb(flt)	.43	01
0000410	PINEY UTILITY DISTRICT	LOUDON	2	972	298,000	C/O-carb	.43	03
0000201	POPLAR GROVE UTILITY DISTRICT	TIPTON	4	3,218	818,000	T-sand(con)	N/A	02
0000092	PRESSMAN'S HOME	HAWKINS	1	23	u	N/A	N/A	05
0000890	PUMP SPRINGS M.H.P.	CLAIBORNE	1	35	u	N/A	N/A	03
0000568	PURYEAR WATER SYSTEM	HENRY	2	350	76,000	T-sand	N/A	02
0000571	RAMER WATER DEPARTMENT	MCNAIRY	2	212	57,000	C-sand	N/A	02
0000572	RED BOILING SPRINGS WATER SYST.	MACON	3	950	603,000	M-carb	.41	04
0000575	REELFOOT UTILITY DISTRICT	LAKE	2	275	145,000	T-sand	N/A	02
0000579	RIDGELY WATER SYSTEM	LAKE	3	920	334,000	T-sand	N/A	02
0000476	RINES' MOBILE HOME PARK	HAMBLEN	1	34	u	N/A	N/A	03
0000580	RIPLEY WATER SYSTEM	LAUDERDALE	4	2,925	1,822,000	T-sand(con)	N/A	02
0000924	RIVER LANDING DEVELOPMENT	MARION	1	21	u	N/A	N/A	01
0000925	RIVERSIDE CAMPGROUND	SEVIER	1	30	u	N/A	N/A	03
0000797	RIVIERA UT CHEROKEE LANDING	HARDEMAN	2	45	30,000	T-sand	N/A	02
0000584	ROAN MOUNTAIN UTILITY DISTRICT	CARTER	2	320	90,000	C-rock	.67	05
0000926	ROBINDALE WATER ASSOCIATION	SULLIVAN	1	17	u	N/A	N/A	05
0000452	ROGERS SPRINGS HOA	HARDEMAN	1	30	12,000	N/A	N/A	02
0000597	ROSSVILLE WATER SYSTEM	FAYETTE	2	142	72,000	T-sand	N/A	02
0000599	RUTHERFORD WATER SYSTEM	GIBSON	2	560	116,000	T-sand	N/A	02
0000605	SALE CREEK UTILITY DISTRICT	HAMILTON	2	457	234,000	C/O-carb	.43	01
0000606	SALTILLO UTILITY DISTRICT	HARDIN	2	594	78,000	Al(C-sand)	N/A	02
0000609	SARDIS WATER SYSTEM	HENDERSON	2	310	47,000	C-sand	N/A	02
0000611	SAVANNAH UTILITY DEPT.	HARDIN	4	5,424	1,514,000	Al(C-sand)	N/A	02
0000613	SAVANNAH VALLEY U. D.	HAMILTON	4	3,600	1,296,000	C/O-carb	.43	01
0000614	SCOTTS HILL WATER SYSTEM	HENDERSON	3	1,148	282,000	C-sand	N/A	02
0000615	SELMER WATER SYSTEM	GILES	4	5,825	2,249,000	C-sand	N/A	02
0000616	SEQUATCHIE WATER WORKS	MARION	2	190	87,000	O-carb(flt)	.43	01
0000911	SEQUOYAH HEIGHTS S/D WTR. SYS.	BLOUNT	1	29	u	N/A	N/A	03
0000921	SEVEN HAWKS WILDERNESS PRG.	HUMPHREYS	1	1	u	N/A	N/A	04
0000879	SHADY GROVE M.H.P.	COFFEE	1	40	u	N/A	N/A	04
0000627	SHARON WATER SYSTEM	WEAKLEY	2	525	140,000	T-sand	N/A	02
0000641	SOMERVILLE WATER SYSTEM	FAYETTE	3	1,519	560,000	T-sand	N/A	02
0000648	SOUTH FULTON WATER SYSTEM	OBION	3	1,738	477,000	T-	N/A	02

						sand(con)		
0000604	ST JOSEPH WATER SYSTEM	LAWRENCE	2	450	111,000	M-carb	.41	04
0000880	STACEY ANN'S M.H.P.	COFFEE	1	42	u	N/A	N/A	04
0000672	STANTON WATER SYSTEM	HAYWOOD	2	273	51,000	T-sand	N/A	02
0000909	SUCK CREEK UTILITY DISTRICT	MARION	2	130	28,900	C/O-carb	.43	01
0000676	SUMMERTOWN WATER SYSTEM	LAWRENCE	2	548	115,000	M-carb	.41	04
0000682	SURGOINSVILLE UTILITY DISTRICT	HAWKINS	2	560	132,000	C/O-carb	.39	05
0000771	TALL OAKS PARK	MCMINN	1	41	u	N/A	N/A	01
0000693	TELLICO PLAINS WATER DEPT.	MONROE	3	1,347	395,000	C/O-carb	.39	01
0000698	TENNESSEE RIDGE WATER SYSTEM	HOUSTON	2	897	186,000	M-carb	.41	04
0000678	THE FARM WATER SYSTEM	LEWIS	1	72	16,000	N/A	N/A	04
0000700	TIPTONVILLE WATER SYSTEM	LAKE	3	870	579,000	Al	N/A	02
0000704	TOONE WATER SYSTEM	HARDEMAN	2	150	185,000	T-sand	N/A	02
0000706	TRACY CITY WATER SYSTEM	GRUNDY	3	1,110	291,000	P-sand	.39	01
0000707	TRENTON WATER SYSTEM	GIBSON	3	2,057	620,000	T-sand	N/A	02
0000710	TREZEVANT WATER SYSTEM	CARROLL	2	440	90,000	T-sand	N/A	02
0000711	TRIMBLE WATER SYSTEM	DYER	2	330	113,000	T-sand(con)	N/A	02
0000712	TROY WATER SYSTEM	OBION	2	690	209,000	T-sand(con)	N/A	02
0000720	UNION CITY WATER DEPT.	OBION	4	5,976	3,070,000	T-sand(con)	N/A	02
0000037	UNION FORK-BAKEWELL U.D.	HAMILTON	2	886	191,000	C/O-carb	.43	01
0000724	VANLEER WATER SYSTEM	DICKSON	2	650	141,000	M-carb	.41	04
0000635	WALDEN RIDGE UTILITY DISTRICT	HAMILTON	3	2,150	542,000	C/O-carb	.43	01
0000728	WALLAND WATER SYSTEM	BLOUNT	1	29	u	N/A	N/A	03
0000730	WARTRACE WATER SYSTEM	BEDFORD	3	675	484,000	M-carb	.41	04
0000732	WATERTOWN WATER SYSTEM	WILSON	2	585	211,000	O-carb	.41	04
0000872	WATTS BAR UTILITY DISTRICT	RHEA	3	1,048	369,000	C/O-carb	.43	01
0000064	WESTERN MENTAL HEALTH INST.	HARDEMAN	2	1	146,000	T-sand	N/A	02
0000298	WHISPERING PINES TRAILER COURT	MADISON	1	50	u	N/A	N/A	02
0000746	WHITE PINE WATER SYSTEM	JEFFERSON	2	760	221,000	C/O-carb	.43	03
0000748	WHITEVILLE WATER DEPARTMENT	HARDEMAN	2	502	123,000	T-sand	N/A	02
0000789	WILMORE ESTATES SUBDIVISION	JEFFERSON	1	41	u	N/A	N/A	03
0000679	WOODLAWN SHORES	DECATUR	1	20	900	N/A	N/A	02
0000446	WOODRUN LAKES S/D	HARDEMAN	1	25	11,000	N/A	N/A	02
0000663	YOST TRAILER PARK	RHEA	1	30	1,735	N/A	N/A	01
0000301	YOUTH TOWN OF TENNESSEE	MADISON	1	6	u	N/A	N/A	02

1: Average Production
u: Production Rate Unknown (Small PWS)

2: Geology
N/A: Not applicable for Category 1 Systems
C-sand: Cretaceous Sand
T-sand: Tertiary Sand
T-sand(con): Tertiary sand (confined)
M-carb: Mississippian Carbonate [Highland Rim Aquifer]
O-carb: Ordovician Carbonate [Central Basin Aquifer]
C/O-carb: Cambrian/Ordovician Carbonate [Valley and Ridge Aquifer]
P-sand: Pennsylvanian Sandstone [Cumberland Plateau Aquifer]
C-rock: Crystalline Rock [Blue Ridge Aquifer]

3: Recharge Value
N/A: Not Applicable for Category 1 systems or those in West Tennessee
[Those with C-sand, T-sand, or T-sand(con)]

4: EAC = Environmental Assistance Centers
01 Chattanooga
02 Jackson
03 Knoxville
04 Nashville
05 Johnson City

Information Sources:

1) Tennessee Division of Water Supply Database, 1993
2) USGS, 1993. Digital Data Acquisition and Development of Geographic Information System coverages for use with the Public Water Supply Wells and Springs in Tennessee. Water Resources Investigation Rept. 92-4178. [MODIFIED]

3) USGS, 1990. Recharge Rates and Aquifer Hydraulic Characteristics for Selected Drainage Basins in Middle and East Tennessee. W.R. Invest. Rept. 90-4015.

APPENDIX 2*
Tennnessee's Hydrogeological Characteristics

Western Tennessee

Alluvial Aquifer. The Alluvial Aquifer in western Tennessee underlies the flood plain of the Mississippi River and its tributaries and the southern end of the Western Valley of the Tennessee River. This aquifer, which consists of sand and gravel with interbeds of clay, is used primarily for rural domestic supplies and for some irrigation. This aquifer is capable of yielding more than 1,500 gallons per minute to wells in the Mississippi River area. In some areas iron concentrations which exceed 1.0 milligram per liter are a problem.

Memphis Sand. In western Tennessee, the Memphis Sand ("500 Foot Sand") is the primary aquifer of use. The Memphis Sand underlies approximately 7,400 mi2 in western Tennessee. It primarily consists of a thick body of sand that contains subordinate lenses or beds of clay or silt at various horizons. The sand ranges from very fine to very coarse, but commonly it is locally fine, fine to medium, or medium to coarse. The Memphis Sand ranges from 0 to about 900 feet in thickness but, where the original thickness is preserved, it is about 400 to 900 feet thick. The base of the Memphis Sand dips westward at rates of about 20 to 50 ft/mi, but it is faulted at many places. The Memphis Sand yields water to wells in most of the area of occurrence and, where saturated, makes up the Memphis aquifer.

Recharge to the Memphis aquifer is from precipitation on the outcrop, which is a broad belt across western Tennessee, or by downward infiltration of water from the overlying fluvial deposits and alluvium. In the outcrop-recharge belt, the Memphis aquifer is under water-table conditions (unconfined), and the configuration of the potentiometric surface is complex and generally conforms to the topography. In the subsurface to the west of the outcrop-recharge belt where the Memphis aquifer is confined (artesian), the potentiometric surface generally gently slopes westward, and water moves slowly in that direction.

Fort Pillow Sand. The Fort Pillow Sand ("1400 Foot Sand") underlies the Memphis Sand and the Flour Island Formation in the western portion of West Tennessee. The Flour Island Formation acts as an upper confining layer to the Fort Pillow and a lower confining layer for the Memphis Sand. The sand is fine to medium; thickest in the southwest portion of the Memphis area; thinnest in the northern and northeastern parts. Once the second principal aquifer supplying the city of Memphis; still used by industry. Principal aquifer providing water for municipal and industrial supplies west of the Mississippi River.

Cretaceous Sand. The Cretaceous Sand aquifer is composed of the McNairy and Coffee Sands, and the Tuscaloosa Formation. The formations crop out in the eastern part of the Coastal Plain and underlie the Tertiary Sand to the west. The Cretaceous Sand aquifer (recently renamed the Western Valley aquifer) is used primarily in and near the outcrop area where it supplies water for municipal, industrial, and rural use. Water in the aquifer is unconfined in the outcrop area and confined in the subsurface farther west. The Cretaceous Sand aquifer is underlain by the Ordovician Carbonate aquifer and the Cambrian-Ordovician Carbonate aquifer (Knox).

Middle Tennessee

Mississippian Carbonate (KARST). The Mississippian Carbonate aquifer (recently renamed the Highland Rim aquifer) consists of flat-lying carbonate rocks of Mississippian age and underlies the Highland Rim physiographic province. Land in the eastern, northern, and southern parts of the province is predominantly undulating, whereas the western part is more dissected and hilly to steep. Altitude of land surface averages about 1,000 feet above sea level. The bedrock formations weather of form a deep (up to 100 feet thick) chert regolith, which stores ground water and releases it to openings in the bedrock. Fractures in the bedrock have been widened selectively by solution, permitting rapid transmission of water, as well as providing some storage. Well yields commonly range from 5 to 50 gal/min.

APPENDIX 2*
Tennnessee's Hydrogeological Characteristics
Continued

Ordovician Carbonate (KARST). The Ordovician Carbonate aquifer (recently renamed the Central Basin aquifer) consists of generally flat-lying carbonate rocks of Ordovician age and underlies the Central Basin physiographic province. The outer part of the Central Basin is predominantly hilly and steep; average altitude of land surface is about 750 feet above sea level. Regolith in the outer part of the Central Basin ranges form less than 2 to more than 10 feet thick. Land in the inner part of the province is predominantly rolling and undulating with an average altitude of about 600 feet above sea level. Regolith cover in the inner part of the province is thin (less than a foot) to absent. Water is stored in and moves through solution-enlarged vertical joints and horizontal bedding planes. Wells commonly yield from 5 to 20 gal/min. At depth (>1000 ft) the Central Basin is underlain by the Knox Aquifer, whose upper formations can provide substantial quantities of water.

Pennsylvanian Sandstone (PREDOMINANTLY FRACTURED ROCK AQUIFER). The Pennsylvanian Sandstone aquifer (recently renamed the Cumberland Plateau aquifer) consists of generally flat-lying sandstone, shale, and conglomerate of Pennsylvanian age and underlies the Cumberland Plateau physiographic province. Land surface in this province is gently rolling to hilly, bordered by a prominent escarpment of both sides. Altitude of the plateau surface is generally between 1,700 and 1,900 feet above sea level; the height of the escarpments averages 900 feet. Regolith is generally less than 4 feet thick. Water is stored in and moves through fractures, faults, and bedding plane openings in the bedrock. Wells commonly yield from 5 to 50 gal/min.

Eastern Tennessee

Cambrian-Ordovician Carbonate (KARST). The Cambrian-Ordovician Carbonate aquifer (recently renamed the Valley and Ridge aquifer) consists of extensively folded and faulted carbonate, sandstone, and shale of Cambrian and Ordovician age underlying the Valley and Ridge physiographic province. The rock formations crop out alternately in long, narrow belts, so that aquifer characteristics show marked areal variability. The ridges range in altitude from about 1,500 to over 7,000 feet above sea level; valleys generally range between 750 and 1,000 feet above sea level. Generally regolith is thin over the shales and sandstones and thick over the limestone. The sandstone and shale units are poor aquifers; nearly all the high producing wells and springs are in the dolomitic limestone formations, particularly the upper formations of the Knox Group (Mascot and Kingsport). The Knox aquifer is frequently singled out as a separate aquifer. Water moves through solution-enlarged fractures, which in areas may form extensive networks. The folding and faulting has produced regional anisotropy in aquifer hydraulic properties, and ground water may move preferentially in strike-parallel or strike-normal directions. Well yields commonly range from 5 to 200 gal/min.

Crystalline Rock Aquifer (FRACTURED ROCK AQUIFER). The Crystalline Rock aquifer (recently renamed the Blue Ridge Aquifer) consists of crystalline rock of Cambrian and Precambrian age underlying the Blue Ridge physiographic province. The province is characterized by extremely rugged terrain, with several mountain peaks higher than 6,000 feet above sea level, and valleys ranging from 1,000 to 1,500 feet above sea level. The aquifer consists of dense, fractured bedrock covered on the lower parts of the slopes with a thick mantle (as much as 100 feet) of regolith, alluvium, and colluvium. The regolith stores ground water, releasing it to fractures in the bedrock. The essentially unmodified fracture openings contribute very little to storage, functioning mainly to transmit water stored in the regolith. Wells yield from 5 to 50 gal/min.

*INFORMATION FOR THIS TABLE WAS DERIVED FROM THE FOLLOWING SOURCES:

1. Tennessee Dept. of Health and Environment; Ground Water Management Strategy, 1988.

2. Bradley, M. W., and Hollyday, E. F., 1985. Tennessee ground-water resources, in National Water Summary 1984: Hydrologic Events, Selected Water Quality trends, and Ground Water Resources: U. S. Geological Survey Water Supply Paper 2275, p. 391-396.

3. U. S. Geological Survey. 1986. Potential for Leakage among Principal Aquifers in the Memphis Area, Tennessee. Water-Resources Investigation Report 85-4295.

APPENDIX 3

GROUND WATER LEVEL MEASUREMENT

General

The measurement of ground water level in wells is frequently conducted in conjunction with ground water sampling. Data from such measurements are needed to determine the "free" water surface and can be used to establish ground water flow direction and gradients.

Total well depth measurements, along with ground water level measurements, are necessary to determine the volume of water in a well casing prior to purging the well during ground water sampling.

All ground water level measurements, as well as total depth measurements, shall be made in reference to an established reference point on the well casing. This reference point shall be documented in field records. To be useful for establishing ground water gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. An arbitrary datum common to all wells in a group may be used for an isolated group of wells, if necessary.

Specific Ground Water Level Measuring Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods (8). Method accuracies are noted below for each of the specific methods described.

> Popper or Bell Sounder bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight barely strikes the water. Measurements shall be recorded to the nearest 0.1 foot.
>
> Weighted Tape - This method is similar to the "bell sounder" method, except that any suitable weight, not necessarily one designed to create an audible pop, can be used to suspend the tape. The weight should, ideally, be made of a relatively inert material and should be easily cleaned. Measurements shall be made and recorded to the nearest 0.1 foot.
>
> Chalked Tape - Chalk rubbed on a weighted steel tape will discolor or be removed when in contact with water. Distance to the water surface can be obtained by subtracting the wet chalked length from the total measured length. The tape should be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. Measurements shall be made and recorded to the nearest 0.01 foot. This method is not recommended if samples are to be collected for analyses of organic or inorganic contaminants.
>
> Electric Water Level Indicators - This instrument consists of a spool of dual conductor wire, a probe attached to the end, and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or buzzer attached to the spool will signal the contact. Penlight or 9-volt batteries are normally used for a power source. Measurements shall be made and recorded to the nearest 0.01 foot.
>
> Other Methods - There are other types of water level indicators and recorders available on the market such as the sliding float method, air line pressure method, and electrical and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot shall not be used.

Total Well Depth Measurement Techniques

The bell sounder, weighted tape, or electric water level indicators described in Section 7.7.2 can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well. Care must be taken in these situations to ensure accurate measurements. All total well depth measurements must be made and recorded to the nearest 0.1 foot.

USEPA, Region IV. 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual.

APPENDIX 4
CONTACTS LIST

ACTION (federally sponsored retired volunteers organization); 265 Cumberland Bend Drive; Nashville, TN 37228; (615) 736-5561.

American Institute of Professional Geologists; 7828 Vance Drive; Suite 103; Arvada, Colorado 80003-2124; (303) 431-0831 or (303) 431-1332.

American Society of Civil Engineers; 345 E. 47th Street; New York, NY 10017-2398; (800) 548-ASCE

American Water Works Association; 6666 West Quincy Avenue; Denver, CO 80235; (303) 794-7711

Austin Peay University; Department of Geology and Geography; Clarksville, TN 37044; (615) 648-7454

Department of Agriculture: (202) 447-7590; Soil Conservation Service (SCS); Agriculture Stabilization and Conservation Service

East Tennessee State University; Department of Geology; Box 22870A; Johnson City, TN 37614

EPA's Publications Office of Ground Water and Drinking Water, call (202) 260-7779.

Ground Water Institute, Department of Civil Engineering,Memphis State University,Memphis,TN,38152; (901) 678-4315.

Middle Tennessee State University; Department of Geography and Geology; Box 9; Murfreesboro, TN 37132; (615) 898-5977

National Ground Water Association; 6375 Riverside Drive;Dublin, Ohio 43017; (800) 551-7379

National Society of Professional Engineers; 1420 King Street;Alexandria, VA 22314; (703) 684-2810

Tennessee Association of Utility Districts, P. O. Box 2529, Murfreesboro, TN 37133-2529; (615) 896-9022

Tn Division of Geology; Map Sales; 13th Floor, L & C Tower; 401 Church Street; Nashville, TN 37243-0445; (615) 532-1516

Tennessee Technological University; Department of Earth Sciences; Box 5125; Cookeville, TN 38505; (615) 372-3523

University of Tennessee - Knoxville; Department of Geological Sciences; 306 G & G Building; Knoxville, TN 37996-1410; (615) 974-2366

United States Geological Survey - Water Resources; 810 Broadway;Suite 500;Nashville, Tn 37243; (615) 736-5424

USGS Map Sales, Box 25286, Federal Center,Denver,CO,80225 (303) 236-7477.

APPENDICES 5A & 5B

Basic Ground-Water Hydrology

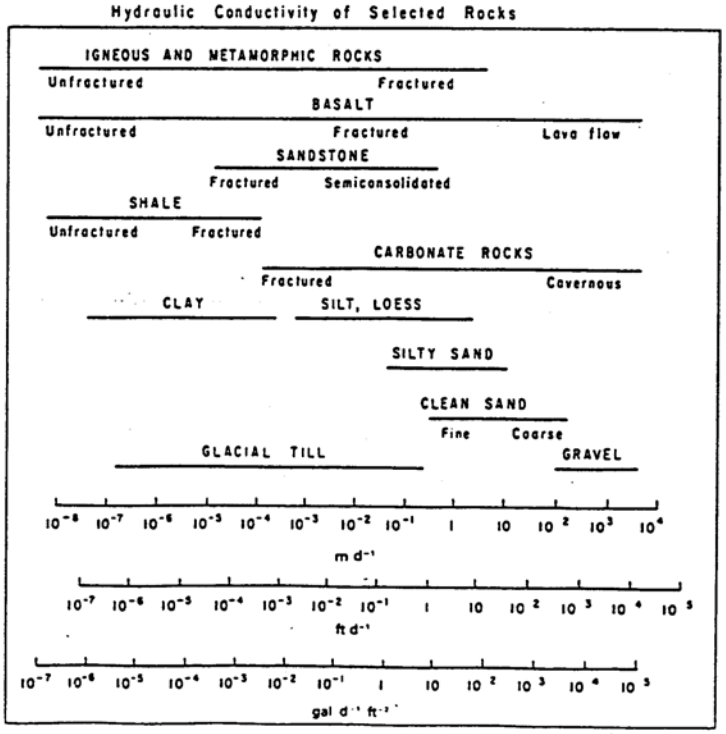
U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2220

SELECTED VALUES OF POROSITY, SPECIFIC YIELD, AND SPECIFIC RETENTION

[Values in percent by volume]

Material	Porosity	Specific yield	Specific retention
Soil	55	40	15
Clay	50	2	48
Sand	25	22	3
Gravel	20	19	1
Limestone	20	18	2
Sandstone (semiconsolidated)	11	6	5
Granite	.1	.09	.01
Basalt (young)	11	8	3

Hydraulic Conductivity of Selected Rocks



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APPENDIX 6

FLUOROMETRIC DETERMINATION OF DYE TRACER

Scope and Application

This method covers the determination of fluorescence as it relates to commercially available tracers. Rhodamine dyes are fluorescent at a wave length of 590 millimicrons, making them detectable without major interferences in all natural waters.

Summary of Method

Fluorescent dyes emit light upon irradiation from an external source. The emitted light is proportional to the tracer concentration within the sample.

Sample Handling

Since tracers are photoreactive, care should be taken to protect samples from light sources.

All samples should be stored in glass containers.

Interferences

Temperature shifts the fluorescent properties of the tracers; thus all samples should be analyzed at the same temperature as the calibration standards.

Natural conditions such as the presence of chlorophyll or tannins and lignins in the waters to be traced can impart background fluorescence. Calibration standards should be made from these ambient waters to account for any potential background.

Sample turbidity may interfere. In highly turbid waters, accuracy may be enhanced by filtration prior to analysis.

Apparatus

Turner Fluorometer Model 10 005.

Calibration glassware.

Standards

Flow Through Configuration

Working stocks (use water sample from study areas as dilution water).

(A) Dilute 1 ml dye to 1 liter dilution water (solution "A" = l ppt).

(B) Dilute 10 mls of solution "A" to 1 liter solution "B" = 10 ppm.

(C) Dilute 100 mls of solution "A" to 1 liter solution "C"= 100 ppm.

Cuvette or Pour Through Configuration

Working stocks (use water sample from study area as dilution water).

(A) Dilute 10 mls dye to 1 liter: solution "A" = 10 ppt

(B) Dilute 10 mls "A" to 1 liter: solution "B" = 100 ppm

(C) Dilute 1 ml "A" to 1 liter: solution "C" = 10 ppm

(D) Dilute 10 mls to 1 liter: solution "D" = 1 ppm

From these stocks

(A) Each ml "B" to 1 liter adds 100 ppb

(B) Each ml "C" to 1 liter adds 10 ppb

(C) Each ml "D" to 1 liter adds 1 ppb

<u>Procedure</u>

Turner Fluorometer; Model 10Ä005

1. Allow fluorometer to warm up for 10 minutes.

2. Using background water, adjust for background fluorescence by setting instrument on most sensitive scale (x31.6 and x100 sensitivity) to read 0.

3. Machine circuitry is designed such that one calibration standard, e.g., 100 ppb, produces linear responses throughout a range of 0.05 to 300 ppb.

4. Above 300 ppb, emissions from the irradiated dye sample interfere with one another producing a nonlinear condition. Thus, when working above 300 ppb calibration curves are required.

5. Even though a single 100 ppb standard produces a linear response in the range of 0.1 to 300 ppb, a second standard, e.g., 10 ppb, should be used as a check.

6. Depending upon sensitivity needs, a 100 ppb standard can be used to provide a wide range of tracer concentrations. A typical application by the Branch involves setting a 100 ppb standard to equal 14 on the minimum sensitivity scale (xMS and x100). With this setting, tracer concentrations in the range of 0.05 to 300 ppb can easily be determined.

<u>Precision and Accuracy</u>

Precision and accuracy for this method have not been established.

Reference

Wilson, James F., Jr., Fluorometric Procedures for Dye Tracing: USGS Techniques for WaterÄResources Investigations, Book 3, Chapter A12 (1968).

Operating and Service Manual, Model 10 Series Fluorometers, Turner Designs, October 1981.

USEPA, Region IV. 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual.

APPENDIX 7
Potential Sources of Ground Water Contamination

Agricultural Sources	
Animal feedlots and burial	Livestock sewage wastes; nitrates; phosphates; chloride; chemical sprays and dips for controlling insects, bacterial, viral, and fungal pests on livestock; coliform and noncoliform bacteria; viruses areas
Manure spreading and storage	Livestock sewage wastes; nitrates areas
Livestock waste disposal	Livestock sewage wastes; nitrates areas
Crop areas and irrigation	Pesticides; fertilizers; gasoline and motor oils from chemical applicators sites
Chemical storage area and containers	Pesticide and fertilizer residues
Farm machinery areas	Automotive wastes; welding wastes
Agricultural drainage wells	Pesticides; fertilizers; bacteria and canals
Residential Sources	
Common household maintenance and hobbies	Common Household Products: Household cleaners; oven cleaners; drain cleaners; toilet cleaners; disinfectants; metal polishes; jewelry cleaners; shoe polishes; synthetic detergents; bleach; laundry soil and stain removers; spot removers and dry cleaning fluid; solvents; lye or caustic soda; household pesticides; photochemicals; printing ink; other common products Wall and Furniture Treatments: Paints; varnishes; stains; dyes; wood preservatives; paint and lacquer thinners; paint and varnish removers and deglossers; paint brush cleaners; floor and furniture strippers Mechanical Repair and Other Maintenance Products: Automotive wastes; waste oils; diesel fuel; kerosene; #2 heating oil; grease; degreasers for driveways and garages; metal degreasers; asphalt and roofing tar; tar removers; lubricants; rustproofers; car wash detergents; car waxes and polishes; rock salt; refrigerants
Lawns and gardens	Fertilizers; herbicides and other pesticides used for lawn and garden maintenance
Swimming pools	Swimming pool maintenance chemicals
Septic systems, cesspools and sewer lines	Septage; coliform and noncoliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides; paints; paint thinner; photographic chemicals; swimming pool chemicals; septic tank/cesspool cleaner chemicals; elevated levels of chloride, sulfate, calcium, magnesium, potassium and phosphate
Underground storage tanks	Home heating oil
Apartments and condominiums	Swimming pool maintenance chemicals; pesticides for lawn and garden maintenance and cockroach, termite, ant, rodent, and other pest control; wastes from onsite sewage treatment plants; household hazardous wastes
Municipal Sources	
Schools and government	Solvents; pesticides; acids; alkalis; waste oils; machinery/vehicle servicing wastes; gasoline and heating oil from offices and grounds storage tanks; general building wastes

Park lands	Fertilizers; herbicides; insecticides
Public and residential areas infested with mosquitoes, gypsy moths, ticks, ants or other pests	Pesticides
Highways, road maintenance	Herbicides in highway right-of-way, road salt (sodium and calcium chloride); road salt anti-caking additives (ferric depots, and deicing operations ferrocyanide, sodium ferrocyanide); road salt anticorrosives (phosphate and chromate); automotive wastes
Municipal sewage treatment plants and sewer lines	Municipal wastewater; sludge; 14 treatment chemicals
Storage, treatment, and disposal ponds, lagoons, and other surface impoundments	Sewage wastewater; nitrates; other liquid wastes; microbiological contaminants
Land areas applied with wastewater or wastewater byproducts	Organic matter; nitrate; inorganic salts; heavy metals; coliform and noncoliform bacteria; viruses; nitrates; sludge; nonhazardous wastes
Storm water drains and basins	Urban runoff; gasoline; oil; other petroleum products; road salt; microbiological contaminants
Combined sewer overflows	Municipal wastewater; treatment chemicals; urban runoff; gasoline; oil; other petroleum products; road salts; microbiological contaminants
Recycling/reduction facilities	Residential and commercial solid waste residues
Municipal waste landfills	Leachate; organic and inorganic chemical contaminants; wastes from households and businesses; nitrates; oils and metals
Open dumping and burning	Organic and inorganic chemicals; metals; oils; wastes from households and businesses sites, closed dumps
Municipal incinerators	Heavy metals; hydrocarbons; formaldehyde; methane; ethane; ethylene; acetylene; sulfur and nitrogen compounds
Water supply wells. monitoring wells, older wells, domestic and livestock wells; unsealed and abandoned wells, and test hole wells	Surface runoff; effluents from barnyards, feedlots, septic tanks, or cesspools; gasoline; used motor oil; salts
Sumps and dry wells	Storm water runoff; spilled liquids; used oil; antifreeze; gasoline; other petroleum products; road salt; pesticides; and a wide variety of other substances
Drainage wells	Pesticides; bacteria
Artificial ground water recharge; Injection	Storm water runoff; excess irrigation water; stream flow; cooling water; treated sewage effluent; other substances that may contain contaminants, such as nitrates, metals, detergents, synthetic organic compounds, bacteria, and viruses
COMMERCIAL SOURCES	
Airports, abandoned airfields	Jet fuels; deicers; diesel fuel; chlorinated solvents; automotive wastes; heating oil; building wastes
Auto repair shops	Waste oils; solvents; acids; paints; automotive wastes; miscellaneous cutting oils
Barber and beauty shops	Perm solutions; dyes; miscellaneous chemicals contained in hair rinses
Boat yards and marinas	Diesel fuels; oil; septage from boat waste disposal areas; wood preservative and treatment chemicals; paints, waxes; varnishes; automotive wastes
Bowling alleys	Epoxy; urethane-based floor finish
Car dealerships (especially those with service departments)	Automotive wastes; waste oils; solvents; miscellaneous wastes
Car washes	Soaps; detergents; waxes; miscellaneous chemicals, tars

	and oil
Campgrounds	Septage; gasoline; diesel fuel from boats; pesticides from controlling mosquitoes, ants, ticks; gypsy moths, and other pests; household hazardous wastes from recreational vehicles (RVs)
Carpet stores	Glues and other adhesives; fuel from storage tanks if forklifts are used
Cemeteries	Leachate; lawn and garden maintenance chemicals
Construction trade areas and materials (plumbing, heating, and air conditioning, painting, paper hanging, decorating, drywall and plastering, acoustical insulation, carpentry, flooring, roofing and sheet metal, wrecking and demolition, etc.)	Solvents; asbestos; paints; glues and other adhesives; waste insulation; lacquers; tars; sealants; epoxy waste; miscellaneous chemical wastes
Country clubs/golf courses	Fertilizers; herbicides; pesticdes for controlling mosquitoes, ticks, ants, gypsy moths, and other pests; swimming pool chemicals; automotive wastes
Dry cleaners	Solvents (perchloroethylene, a.k.a. tetrachloroethylene; petroleum solvents; Freon); spotting chemicals(trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate)
Funeral services and crematories	Formaldehyde; wetting agents; fumigants; solvents
Furniture repair and finishing shops	Paints; solvents; degreasing and solvent recovery sludges
Gasoline service stations	Oils; solvents; miscellaneous wastes -- particularly through floor drains
Hardware/lumber/parts stores	Hazardous chemical products in inventory; heating oil and fork lift fuel from storage tanks; wood-staining and treating products such as creosote
Heating oil companies	Heating oil; wastes from truck maintenance areas; underground storage tanks
Horticultural practices, garden nurseries, florists	Herbicides, insecticides; fungicides, and other pesticides; fertilizer
Jewelry/metal plating shops	Sodium and hydrogen cyanide; metallic salts; hydrochloric acid; sulfuric acid; chromic acid
Laundromats	Detergents; bleaches; fabric dyes
Medical Institutions	X-ray developers and fixers; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; dental acids; miscellaneous chemicals
Office buildings and office	Building wastes; lawn and garden maintenance chemicals; gasoline and motor oil complexes
Paint stores	Paints; paint thinners; lacquers; varnishes; other wood treatments
Pharmacies	Spilled and returned products
Photography shops; photo processing laboratories	Biosludges; silver sludges; cyanides; miscellaneous sludges
Print shops	Solvents; inks; dyes; oils; photographic chemicals
Railroad tracks and yards	Diesel fuel; solvents; herbicides for rights-of-way; creosote for preserving wood ties
Research laboratories	X-ray developers and fixers; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; solvents; infectious materials; drugs; disinfectants(quartenary ammonia; hexachlorophene, peroxides, chlornexade, bleach); miscellaneous chemicals
Scrap and junk yards	Any wastes from businesses and households; oils; metals; PCBs

Sports and hobby shops	Gunpowder and ammunition; rocket engine fuel; model airplane glue
Above-ground and underground storage tanks	Heating oil; diesel fuel; gasoline; other petroleum products; other commercially used chemicals
Transportation services for passenger transit (local and interurban)	Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes
Veterinary services	Solvents; infectious materials; vaccines; drugs; disinfectants (quarternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); X-ray developers and fixers
INDUSTRIAL SOURCES	
Material stockpiles (coal, metallic ores, phosphates, gypsum)	Acid drainage; other hazardous and nonhazardous wastes
Waste tailing ponds (commonly for the disposal of mining wastes)	Acids; metals; dissolved solids; radioactive ores; other hazardous and nonhazardous wastes
Transport and transfer stations (trucking terminals and rail yards)	Fuel tanks; repair shop wastes; other hazardous and nonhazardous wastes; particularly from spills and leaks
Above ground and underground storage tanks and containers	Heating oil; diesel and gasoline fuel; other petroleum products; hazardous and nonhazardous materials and wastes
Storage, treatment, and disposal ponds, lagoons, and other surface impoundments	Hazardous and nonhazardous liquid wastes; septage; sludge
Chemical landfills	Leachate; hazardous and nonhazardous materials; nitrates
Operating and abandoned production and exploratory wells (for gas, oil, coal, geothermal, and heat recovery); test hole wells; monitoring and excavation wells	Metals; acids; minerals; sulfides; other hazardous and nonhazardous chemicals
Injection wells	Hazardous and nonhazardous industrial wastes; oil-field brines
Oil Well drilling operations	Brines associated with oil and gas operations
INDUSTRIAL PROCESSES (PRESENTLY OPERATING OR DEFUNCT)	
Asphalt plants	Petroleum derivatives
Communications equipment manufacturers	Nitric, hydrochloric, and sulfuric acid wastes; heavy metal sludges; copper contaminated etchant (e.g., ammonium persulfate); cutting oil and degreasing solvent(trichloroethane, Freon, carbon tetrachloride, or trichloroethylene); waste oils; corrosive soldering flux; paint sludge; waste plating solution
Electric and electronic equipment manufacturers and storage facilities	Cyanides; metal sludges; caustics (chromic acid); solvents; oils; alkalis; acids; paints and paint sludges; calcium fluoride sludges; methylene chloride; perchloroethylene (a.k.a. tetrachloroethylene); trichloroethane; acetone; methanol; toluene; PCB's
Electroplaters	Boric, hydrochloric, hydrofluoric, and sulfuric acids; sodium and potassium hydroxide; chromic acid; sodium and hydrogen cyanide; metallic salts
Foundries and wastes; metal fabricators	Paint wastes; acids; heavy metals; metal sludges; plating wastes; oils; solvents; explosive waste foundry sand
Furniture and fixtures manufacturers	Paints; solvents; degreasing sludges; solvent recovery sludges
Hazardous Waste Processing, Recovery, Transfer, Treatment, Storage & Disposal	Solvents; degreasers; paints; organic and inorganic chemicals; other hazardous and nonhazardous chemicals
Machine and metalworking shops	Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers

	(tetrachloroethylene, trichloroethylene); metal marking fluids; mold-release agents
Mining operations(surface and underground), underground storage mines	Mine spoils or tailings that often contain metals; acids; highly corrosive mineralized waters; metal sulfides
Unsealed abandoned mines and gravel pits used as waste pits	Metals; acids; minerals; sulfides; other hazardous and nonhazardous chemicals
Paper mills	Metals; acids; minerals; sulfides; other hazardous and nonhazardous chemicals; organic sludges; sodium hydroxide; chlorine; hypochlorite; chlorine dioxide; hydrogen peroxide
Petroleum production and storage companies, secondary recovery of petroleum(waste oil recycling)	Hydrocarbons; oil field brines; solvents; heavy metals; waste oil
Industrial pipelines	Corrosive fluids; hydrocarbons; other hazardous and nonhazardous materials and wastes
Photo processing laboratories	Cyanides; biosludges; silver sludges; miscellaneous sludges
Plastic materials and synthetic producers	Solvents; oils; miscellaneous organics and inorganics (phenols and resins); paint wastes; cyanides; acids; alkalis; wastewater treatment sludges; cellulose esters; surfactants; glycols; phenols; formaldehyde; peroxides; etc.
Primary metal industries (blast furnaces, steel works and rolling mills)	Heavy metal wastewater treatment sludge; pickling liquor; waste oil; ammonia scrubber liquor; acid tar sludge; alkaline cleaners; degreasing solvents; slag; metal dust; “baghouse dust”
Publishers, printers, and allied industries	Solvents; inks; dyes; oils; miscellaneous organics; photographic chemicals
Public utilities (phone, electric power, gas) from utilities rights-of-way	PCB's from transformers, capacitors and pumps (large gas pipelines); oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides
Sawmills and planers	Treated wood residue (copper quinolate, mercury, sodium bazide); tanner gas; paint sludges; solvents; creosote; pentachlorophenol; coating and gluing wastes
Stone, clay, and glass manufacturers	Solvents; oils and grease; alkalis; acetic wastes; asbestos; heavy metal sludges; phenolic solids or sludges; metal-finishing sludge
Welders	Oxygen, acetylene
Wood preserving facilities	Wood preservatives; creosote; pentachlorophenol; arsenic; copper; chromium

In general, ground water contamination stems from the misuse and improper disposal of liquid and solid wastes; the illegal dumping or abandonment of household, commercial, or industrial chemicals; the accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; or the improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities. When the sources in this table are used and managed properly, ground water contamination is not likely to occur.

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APPENDIX 8
SUMMARY OF WELLHEAD PROTECTION TOOLS

TOOLS FOR PWS TO USE

	Applicability to Wellhead Protection
Chemical Handling and Storage	Ensure that no chemicals other than those to treat drinking water are stored in the vicinity of well or spring. Ensure that no chemicals applied within 100 foot (minimum) of well or spring through written agreements with adjacent property owners where necessary. Property purchase if feasible.
Designation of Wellhead Protection Area	Official designation of wellhead protection areas provides valuable input and emphasis to government agencies in the siting of facilities and the cleanup of contamination sites.
Maintenance of Wellcasing/ Springbox & other routine maintenance	Maintain casing and concrete pad around well to keep contaminants from entering alongside casing. Keep springbox/ protective cover at spring in good repair to keep surface contaminants out.

Public Education	Informed public and industries more likely to be concerned about where their water comes from and the additional costs if contamination occurs. Raising environmental consciousness of community, particularly school children will be long range benefit.
Observe Activities within WHPA	Provide local "eyes and ears" to Division of Water Supply for coordinated State regulatory support.
Submit Wellhead Protection Area to Local Government	Consideration of area in land management strategies described below. Review by PWS of zoning changes, etc. within WHPA that may impact water supply.

LAND MANAGEMENT TOOLS**

(Planning/Zoning Agencies & County Government)

Regulatory: Zoning	Applicability to Wellhead Protection	Land Use Practice	Considerations	Administrative Concerns
Overlay GW Protection Districts (Draw WHPAs on existing zoning maps, similar to way floodplains	Used to map wellhead protection areas (WHPAs). Provides for identification of sensitive areas for protection. Used in conjunction with other	Community identifies WHPAs on practical base/zoning map.	Well-accepted method of identifying sensitive areas.	Requires staff to develop overlay map. Inherent nature of zoning provides "grandfather" protection to pre-existing uses and structures.

addressed)	tools that follow.			
Prohibition of Various Land Uses	Used within mapped WHPAs to prohibit ground water contaminants and uses that generate contaminants.	Community adopts prohibited uses list within their zoning ordinance.	Well-organized function of zoning Appropriate techniques to protect natural resources from contamination.	Requires amendment to zoning ordinance. Requires enforcement by both visual inspection and onsite investigations.
Special Permitting (Design & Operating Standards)	Used to restrict uses within WHPAs that may cause ground water contamination if left unregulated.	Community adopts special permit"thresholds" for various uses and structures within WHPAs. Community grants special permits for"threshold" uses only if ground water quality will not be compromised.	Well-organized method of segregating land uses within critical resource areas such as WHPAs. Requires case- by-case analysis to ensure equal treatment of applicants.	Requires detailed understanding of WHPA sensitivity by local permit granting authority. Requires enforcement of special permit requirements and onsite investigations.
Large-Lot Zoning	Used to reduce impacts of residential development by limiting numbers of units within WHPAs	Community "down zones" to increase to increase minimum acreage needed for residential development.	Well-recognized prerogative of local government. Requires rational connection between minimum lot size selected and resource protection goals. Arbitrary large lot zones have been struck down without logical connection to Master Plan or WHPA program.	Requires amendment to zoning ordinances.
Transfer of Development Rights	Used to transfer development from WHPAs to locations outside WHPAs.	Community offers transfer option within zoning ordinance. Community identifies areas where development is to be transferred "from" and "to."	Accepted land use planning tool.	Cumbersome administrative requirements. Not well suited for small communities without significant administrative resources.
Cluster/PUD Design	Used to guide residential development inside of WHPAs. Allows for "point source" discharges that are more easily monitored.	Community offers cluster/PUD as development as an option within zoning ordinance. Community identifies areas where cluster/PUD is allowed (i.e.,	Well-accepted option for residential land development.	Slightly more complicated to administer than traditional "grid" subdivision. Enforcement/ inspection requirements are similar to "grid" subdivision.

		within WHPAs).		
Growth Controls/ Timing	Used to time the occurrence of development within WHPAs. Allows communities the opportunity to plan for wellhead delineation and protection.	Community imposes growth controls in form of building caps, subdivision phasing, or other limitation tied to planning concerns.	Well-accepted option for communities facing development pressures within sensitive resource areas. Growth controls may be challenged if they are imposed without a rational connection to the resource being protected.	Generally complicated administrative process. administrative staff to issue permits and enforcement growth ordinances.
Performance Standards	Used to regulate development within WHPAs by enforcing predetermined standards for water quality. Allows for aggressive protection of WHPAs by limiting development within WHPAs to an acceptible level.	Community identifies WHPAs and established "thresholds" for water quality. Performance standards must be enforced on a case-by-case basis.	Adoption of specific WHPA performance standards requires sound technical support.	Complex administrative requirements to evaluate impacts of land development within WHPAs.
Regulatory: Subdivision Control				
Drainage Requirements	Used to ensure that subdivision road drainage is directed outside WHPAs. Used to employ advanced engineering designs of subdivision roads within WHPAs.	Community adopts stringent subdivision rules and regulations to regulate road drainage/runoff in subdivisions within WHPAs.	Well-accepted purpose of subdivision control.	Requires moderate level of inspection and enforcement by administrative staff.
Regulatory: Health Regulations				
Underground Fuel Storage Systems	Used to prohibit underground fuel storage systems (USTs) within WHPAs. Used to regulate USTs within WHPAs.	Community adopts health/ zoning ordinance prohibiting USTs within WHPAs. Community adopts special permit or performance	Well-accepted regulatory option for local government.	Prohibition of USTs require little administrative support. Regulating USTs requires moderate amounts of administrative support for

		standards for use of USTs within WHPAs.		inspection followup and enforcement.
Privately Owned Wastewater Treat ment Plants (Small Sewage Treatment Plants)	Used to prohibit small sewage treatment plants (SSTP) within WHPAs.	Community adopts health/ zoning ordinance within WHPAs. Community adopts special permit or performance standards for use of SSTPs within WHPAs.	Well-accepted regulatory option for local government.	Prohibition of SSTPs require little administrative support. Regulating SSTPs requires moderate amount of administrative support of inspection followup and enforcement.
Septic Cleaner Ban	Used to prohibit the application of certain solvent septic cleaners, a known ground water contaminant, within WHPAs.	Community adopts health/ zoning ordinance prohibiting the use of septic cleaners containing 1,1,1 trichloroethane or other solvent compounds	Well-accepted method of protecting ground water quality within WHPAs.	Difficult to enforce even with sufficient administrative support.
Septic System Upgrades	Used to require periodic inspection and upgrading of septic systems.	Community adopts health/zoning ordinance requiring inspection and, if necessary, upgrading systems on a time basis (e.g., every two years) or upon title/ property transfer.	Well-accepted purview of government to ensure protection of ground water.	Significant administrative resources required for this option.
Toxic and Hazardous Materials Handling Regulations	Used to ensure proper handling and disposal of toxic materials/ waste.	Community adopts health/zoning ordinance requiring registration and inspection of all businesses within WHPAs using toxic materials above certain quantities.	Well-accepted as within the purview of government to ensure protection of ground water.	Requires administrative support and onsite inspections.
Private Well Protection	Used to protect private onsite water supply wells.	Community adopts health/zoning ordinance to require permits for new private wells and to ensure appropriate well-to-septic-system setbacks. Also requires pump and water	Well-accepted as within the purview of government to ensure protection of ground water.	Requires administrative support and review of applications.

		quality testing.		
Non-regulatory: Land Transfer and Voluntary Restrictions				
Sale/Donation	Land acquired by a community within WHPAs, either by purchase or donation. Provides broad protection to the ground water supply.	As non-regulatory technique, communities generally work in partnership with nonprofit land conservation organizations.	There are many legal consequences of accepting land for donation or sale from the private sector, mostly involving liability.	There are few administrative requirements involved in accepting donations or sales of land from the private sector. Administrative requirements for maintenance of land accepted or purchased may be substantial, particularly if the community does not have a program for open space management.
Conservation Easements	Can be used to limit development within WHPAs.	Similar to sales/donations, conservation easements are generally obtained with the assistance of nonprofit land conservation organization.	Same as above.	Same as above.
Limited Development	As the title implies, this technique limits development to portions of land parcel outside of WHPAs.	Land developers work with community as part of a cluster/PUD to develop limited portions of a site and restrict other portions, particularly those within WHPAs.	Similar to those noted in cluster/PUD under zoning	Similar to those noted in cluster/PUD under zoning.
Non-regulatory: Other				
Monitoring	Used to monitor ground water quality within WHPAs.	Communities establish ground water monitoring program within WHPA. Communities require developers within WHPAs to monitor ground water quality downgradient	Accepted method of ensuring ground water quality.	Requires moderate administrative staffing to ensure routine sampling and response if sampling indicates contamination.

		from their development.		
Contingency Plans	Used to ensure appropriate response in cases of contaminant release or other emergencies within WHPA.	Community prepares a contingency plan involving wide range of municipal/county officials.	None.	Requires significant up-front planning to anticipate and be prepared for emergencies.
Hazardous Waste Collection	Used to reduce accumulation of hazardous materials within WHPAs and communities at large.	Communities, in cooperation with the state, regional planning commission, or other entity, sponsor a "hazardous waste collection day" several times per year.	There are several legal issues raised by the collection, transport, and disposal of hazardous waste.	Hazardous waste collection programs are generally sponsored by government agencies, but administered by a private contractor.
Public Education	Used to inform community residents of the connection between land use within WHPAs and drinking water quality.	Communities can employ a variety of public education techniques ranging from brochures detailing their WHPA program, to seminars, to involvement in events such as hazardous waste collection days.	No outstanding legal considerations.	Requires some degree of administrative support for programs such as brochure mailing to more intensive support for seminars and hazardous waste collection days.
Legislative:				
Regional WHPA Districts	Used to protect regional aquifer systems by establishing new legislative districts that often transcend existing corporate boundaries.	Requires state legislative action to create a new legislative authority	Well-accepted method of protecting regional ground water resources.	Administrative requirements will vary depending on the goal of the regional district. Mapping of regional WHPAs requires moderate administrative support, while creating land use controls within the WHPA will require significant administrative personnel and support.
Land Banking	Used to acquire and protect land within WHPAs.	Land banks are usually accomplished with a transfer tax established by state government empowering local government to impose a tax	Land banks can be subject to legal challenge as an unjust tax, but have been accepted as a legitimate method of raising revenue for resource protection.	Land banks require significant administrative support if they are to function effectively.

on the transfer of land from
one party to another.

** EPA Seminar Publication; Wellhead Protection: A Guide for Small Communities; Table 4-6; EPA/625/R-93/002

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APPENDIX 9
POTENTIAL CONTAMINANT SOURCE INVENTORY
PRELIMINARY CHECKLIST

Public Water System ____________________

PWSID# ____________________

County ____________________

Well or Spring Name/# ____________________

USGS Quad Sheet(s) ____________________

POTENTIAL POLLUTION SOURCES

(Assign Number to correspond to map)

TRANSPORTATION

Major Highway ____________________

Railyard/Railroad ____________________

Airport ____________________

Interstate Trucking Operation ____________________

Dept of Transportation (County Garage) Facility ____________________

Other ____________________

AGRICULTURE*

Fruit & Vegetable ____________________

Nursery ____________________

Hog or Cattle Feedlots ____________________

Lagoons ____________________

Cotton or Tobacco ____________________

Other ____________________

APPENDIX 9
POTENTIAL CONTAMINANT SOURCE INVENTORY
PRELIMINARY CHECKLIST
Continued

INDUSTRIES**

Industrial Park ____________________

Chemical/Pesticide Mfg ____________________

Textile Mfg ____________________

Electronics Mfg ____________________

Petroleum Refining& Storage ____________________

Asphalt Plant ____________________

Metal Treating/Plating ____________________

Metal Fabricating____________________

Drum Cleaning/Reclaiming ____________________

Junkyards/Recycling Operations

____

Hazardous Waste Treatment or Storage
Facilities ____________________

Gas Stations ____________________

Landfills/Dumps ____________________

Wood Treatment ____________________

DISCHARGES

High Density of
Septic Systems ____________________

Underground Injection/
Return Flow ____________________

Major Sewer Lines ____________________

Sewer Plants ____________________

Sewer Uplift Stations ____________________

APPENDIX 9
POTENTIAL CONTAMINANT SOURCE INVENTORY
PRELIMINARY CHECKLIST
Continued

Lagoons (Industrial
or Municipal) ______________________________

Sludge Spreading ______________________________

Geologic Setting

Floodplain ______________________________

Sinkholes ______________________________

Open ______________________________

Streams in bottom ______________________________

Disappearing Streams ______________________________

Dry Streams ______________________________

Bluff Edge/Plateau ______________________________

Rivers or Streams ______________________________

Ridge/Hilltop or Side ______________________________

INDUSTRIES, GENERAL

Small or Large Drum
Storage Areas ______________________________

Small or Large
Above Ground Tanks ______________________________
Small or Large
Underground Tanks ______________________________

Small or Large
Material or Waste Piles ______________________________

COMMERCIAL/RESIDENTIAL

Laundry or Car Wash ______________________________

Dry Cleaning ______________________________

Retail/Commercial Area ______________________________

Urban Residential ______________________________

APPENDIX 9
POTENTIAL CONTAMINANT SOURCE INVENTORY
PRELIMINARY CHECKLIST
Continued

Suburban and/or
Developing ______________________________

Rural
(evidence of pit privy) ______________________________

OTHER

Superfund Sites ______________________________

Quarries ______________________________

Gravel Pits ______________________________

Cemeteries ______________________________

Abandoned Wells______________________________

Old Dump Sites ______________________________

* In Addition Contact County Agriculture Extension Agent and Soil Conservation Service for pesticide use in Wellhead Protection
Area (Zones 1 & 2)
** In Addition Contact Local Fire Deparment for Community Right-to-Know Information for chemical use in Wellhead Protection
Area (Zones 1 & 2)

OTHER COMMENTS

____

____

____

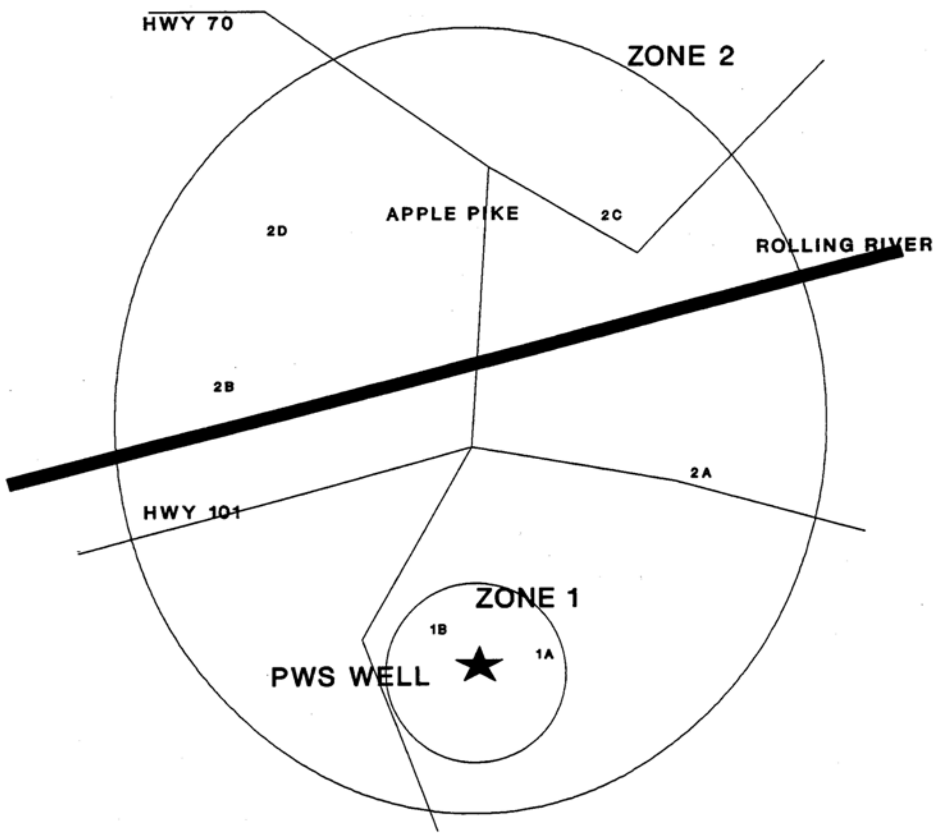
____

____

____

____

EXAMPLE POTENTIAL CONTAMINANT SOURCE INVENTORY MAP



KEY

- 1A Jones Drum Recycling
- 1B Smith Grocery & Gas
- 2A Wallawalla Mfg
- 2B John Doe Dry Cleaning
- 2C Chemplant International
- 2D Airport

APPENDIX 10

XYZ UTILITY DISTRICT
P.O.Box 1234
Quietville, TN 37999

The Honorable John Doe
Harmony County Executive
Harmony County Courthouse
Peaceful, TN 37998

Mr.John Order, Chairman
Harmony County Regional Planning Commission
Suite 4
Harmony County Office Building
Peaceful, TN 37998

RE: XYZ Utility District Wellhead Protection Program
Designation of Wellhead Protection Areas

Gentlemen:

XYZ Utility District intends to pursue a Wellhead Protection Program to protect its wells/springs and their designated recharge areas and hereby requests the assistance and cooperation of Harmony County and the Harmony County Regional Planning Commission in implementing this Program. XYZ Utility District requests that the designated wellhead protection areas be considered in any zoning or ordinance actions and that XYZ be offered the opportunity to review and comment on such actions which fall within the wellhead protection areas.

Rule 1200-5-1-.34(1)(f)5 under the Tennessee Safe Drinking Water Act requires that the public water supply systems developing Wellhead Protection Program notify and request assistance from the governing county body and the county/regional planning commission of the location of each well or spring and the boundaries and extent of the wellhead protection areas surrounding each well or spring.

It is critical that this program is established because it is tied to a monitoring waiver program which will allow XYZ to save thousands of dollars in sampling costs over the next several years. In addition, preventing contamination from impacting our supply will save XYZ from having to add very expensive treatment systems which would end up costing all its customers considerably more on their water bills.

Zone 1 for wells/springs operated by the XYZ Utility District are shown on the enclosed maps. Zone 1 is a fixed radius and is designed for more immediate contamination threats. {Category 1 systems also have Zone 2 designated} Zone 2 (the longer term Wellhead Management Zone) will be designated later hydrogeologically and you will be informed of that area as soon as it is approved by the State. I will be glad to discuss any aspect of the program with you at any time.

APPENDIX 10
Continued

The Honorable John Doe
Mr. John Order
Page 2

I look forward to working with each of you in the implementation of this program to protect the drinking water supplies which serve our citizens.

Sincerely,

Edward M. Goodwater
General Manager
XYZ Utility District

APPENDIX 11

WELLHEAD PROTECTION PLAN

XYZ UTILITY DISTRICT

Quietville, Harmony County, Tennessee

The XYZ Utility District of Quietville, Tennessee has developed the following written policy in protecting its wellhead protection area:

1) XYZ will not store chemicals other than those used for drinking water treatment within the wellhouse or adjacent to the well or spring.

2) XYZ will not allow chemicals to be applied adjacent to the well or spring (minimum of 100 feet) and has agreements from adjacent property owners, where appropriate.

3) XYZ has identified the wellhead protection areas to the local planning/zoning commission and county government and asked for them to consider protective measures for these areas in the form of {local ordinances, zoning considerations, etc.}. XYZ has also asked to be allowed to review and comment on actions that fall within the wellhead protection area.

4) XYZ will actively observe the activities within the designated wellhead protection areas and report pertinent information to the Division of Water Supply. XYZ will update the Potential Contaminant Source Inventory when significant changes occur within the wellhead protection areas. XYZ will update the Wellhead Protection Plan every three years by reviewing the wellhead protection areas at least annually for any new potential contaminant sources.

5) XYZ will insert in the local Harmony Times newspaper the required information about wellhead protection upon approval of the wellhead protection plan and will continue to do so at 6 month intervals.

6) Contingency Planning -- in the case of an emergency spill which could impact the water source within the Wellhead Protection Area, XYZ will contact:

    Tennessee Emergency Management Agency
    at 1-800-262-3300
    within 24 hours

    Harmony County Sheriff's Office
    at ***-****
    within 24 hours

APPENDIX 11
Continued

Tennessee Division of Water Supply
at (615) 532-0191
within 72 hours

Contingency Plan

To fulfill the Contingency Planning portion of the Wellhead Protection Regulations, XYZ has provided information on the following:

a. A listing of all sources of drinking water currently available to the Public Water Supply;

b. An estimate of the quantity of water available from currently connected sources;

c. Identification of additional water supplies that will meet future needs;

d. Identification of any actions that have been taken by local governments to protect designated future water supplies.

e. References to the Wellhead Protection Plan that detail protection plans for designated future water supplies.

f. A schedule for incorporation of designated future water supplies into the water system;

g. An estimation of the resources (authority, consulting expenses, capital expenses) necessary to incorporate designated future water supplies into the water system by the schedule detailed in item f;

h. Identification of the financial resources available to incorporate designated future water supplies into the water system.

Reference has been made to the XYZ's approved Emergency Plan will be sufficient for those items which are addressed in the Emergency Plan.

Potential Contaminant Source Inventory

Attached is the listing of potential contaminant sources within Zones 1 and 2 of the wellhead protection areas for XYZ's wells and springs (Zones and wells/springs marked and labeled) with a map identifying the potential sources by number and/or letter {See map on page 96 at end of Appendix 10}.

APPENDIX 11
Continued

#1A Jones Drum Recycling (shows as 1A in Zone 1 on map)
Chemicals reported:
- solvents
- paint residues

#1B Smith's Grocery & Gas
- Gasoline

#2A Wallawalla Manufacturing (2A in Zone 2 on map)
Chemicals reported in Community-Right-To-Know Information:
- Trichloroethylene
- Benzene
- Managanese
- Lead

#2B John Doe Dry Cleaning
- Tetrachloroethylene

#2C Chemplant International
Chemicals reported in CRK Information:
- Styrene
- Acetone
- Napthalene

#2D Airport
- Aviation Fuel
- Cleaning/degreasing solvents
- Anti-freeze (ethylene glycol)